

# The American Midland Naturalist

Published Quarterly by The University of Notre Dame, Notre Dame, Indiana

VOL. 50

JULY, 1953

No. 1

## Revisionary Studies in the Ant Tribe Dacetini

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### Introduction

The tribe Dacetini is a rather large group containing 27 described genera and about 260 or 270 described and undescribed species presently in collections. In stating the number of species, I have excluded all the synonyms known to me in the tribe. The Dacetini have been placed by all relatively recent major authors in the subfamily Myrmicinae of the single family representing all ants, the Formicidae. The placement with the Myrmicinae appears the most correct situation for the present, but the tribe seems so distinctive in many ways important to phylogenetic considerations that future revision of the subfamily, now so hopelessly tangled systematically, may see the Dacetini separated as an independent group.

Like the remainder of the *Myrmicinae*, all dacetines possess a two-segmented, clearly differentiated pedicel and a well developed sting. Characterization beyond this is extremely difficult due to the great number of exceptionally bizarre modifications found among the genera, some of which have developed secondarily characters conferring non-dacetine habitus of a type convergent to that of ants in other tribes.

However, it may be stated that any myrmicine ant having (a) less than six segments in the antennal funiculi together with whitish spongiform appendages or thin lamellate lateral wings on either or both nodes of the pedicel, or (b) having a flattened, more or less pyriform head, narrowed anteriorly and with a deep, broad posterior occipital excision in combination with a pair of elongate, linear mandibles, each bearing two or three large apical teeth and an oblique, usually partly concealed spine or tooth at the base of the inner border, or (c) showing a combination of the characters of (a) and (b), is a member of the tribe Dacetini.

The reasons for the exclusion from the tribe Dacetini of *Peronomyrmex* Viehmeier, *Weberidris* Donisthorpe and the genera related to *Basiceros* Schulz and *Rhopalothrix* Mayr have been given in some detail in Part IV of this revision (1949). In my opinion, none of these genera can be considered at all closely related to any true dacetine genus.

In their habits, the very great majority of dacetine species are probably to be considered cryptobiotic predators of Silvestri's "microgenton." In the *Strumigenys* complex, species of at least two genera are known to feed on Collembola almost to the exclusion of any other prey. The normal prey of the other complexes is not known, but I hope to be able to give information on these at a later date. A few of the primitive species, such as *Daceton* of Amazonia, are arboreal, epigaic huntresses, apparently lying in wait for their prey on the bark of trees and in similar situations. The spiny armature so well developed in *Daceton* shows that it is primarily arboreal, and this is further confirmed by the large and prominent eyes. *Daceton* seems by all odds to be the most primitive living dacetine, and the presence of similarly-placed but reduced spines in other primitive genera now inhabiting the soil or other cryptobiotic environments seems to indicate that relegation to the microgenton has been a secondary measure forced upon the great majority of dacetine species as a retreat before superior competitors.

### Subtribal Grouping of the Dacetine Genera by "Generic Complexes"

The Dacetini may be grouped into five generic complexes probably reflecting major phyletic lines. *Hypomyrmex* Emery is known only from a single specimen in the Sicilian (Miocene) Amber, and its relationships are presently unclear. The four remaining (Recent) complexes are listed with annotations:

#### DACETON COMPLEX

Eyes dorsolateral or lateral; antennal funiculus with 10 segments. Palpi segmented 5, 3.

Genera: *Daceton* Perty and *Acanthognathus* Mayr, both Neotropical.



## ORECTOGNATHUS COMPLEX

Eyes lateral; funiculus 4-segmented, the second segment long. Palpi segmented 5, 3.

*Genera:* *Orectognathus* Fred. Smith and *Arnoldidris* Brown, both Australasian.

## EPOPOSTRUMA COMPLEX

Eyes dorsolateral; funiculus 3- or 5-segmented, second segment not longer than the rest. Palpi segmented 5, 3.

*Genera:* *Epopostruma* Forel, *Alistruma* Brown, *Mesosturma* Brown, *Clarkisturma* Brown, *Colobostruma* Wheeler, *Hexadacton* Brown (Australasian) and *Microdacton* Santschi (Ethiopian).

## STRUMIGENYS COMPLEX

Eyes ventrolateral, placed within or beneath the antennal scrobes; antennal funiculi with 3, 4 or 5 segments, the apical segment much the longest. If with 5 segments, the second and third are usually much reduced. Palpi much reduced, segmented 1, 1 in all examined.

*Genera:* The *Strumigenys* complex contains 16 presently recognized genera, distributed widely over the planet in tropical and temperate regions. The genus *Strumigenys* alone contains more than half of the known dacetine species (described and undescribed), and the whole complex accounts for approximately nine-tenths of the species in the tribe. The generic organization of the complex will be treated separately below.

The relationships among the five major complexes or subtribes are not very evident, but it does seem clear enough that the *Strumigenys* complex is the most highly derivative and probably the most recently evolved of these, chiefly because of the very great reduction of the maxillary and labial palps. The dacetine worker archetype probably combined the form and polymorphism of *Dacton* with the sculpture of *Acanthognathus*, *Epopostruma*, etc., and it must have had ten-segmented funiculi and a 5, 3 palpal formula. It undoubtedly had long paired spines on the pronotum and mesonotum as well as on the propodeum, and it seems that the nodes of the pedicel may also have had bilaterally-paired teeth of some kind. It was probably arboreal or subarboreal in habit. It gave rise to what must have been a flourishing group in the geological past, and the members of this group showed radiation and adaptation to a number of different habitats, including the cryptobiotic ones.

Adaptation to the cryptobiotic environments progressed in a somewhat convergent way in several branches of the group that had differentiated; the spinose armature became weaker and began to disappear, the body size and eyes grew smaller together. The sculpture altered and became finer, the worker polymorphism of the more primitive forms reduced to a highly restricted monomorphism, and fusion of the funicular segments progressed rapidly. All of these modifications may be seen today in other ant tribes that have produced cryptobionts from an epigaeic stock. In the dacetines, one of the interesting convergent lines of development has concerned the *Epopostruma* and *Strumigenys* complexes, both of which have produced forms with secondarily shortened triangular mandibles with serially dentate or dentic-

ulate masticatory borders. This has apparently come about in different ways in the two complexes, and appears to be happening a third time in the case of the series *Strumigenys*-*Pyramica*-*Neostruma* (see figs. 35-38). In the *Epopostruma* complex, the series *Epopostruma*-*Mesostruma*-*Alistruma* shows very clearly how the *Epopostruma* type of mandible, similar to that of *Strumigenys*, has gradually had its inner border extended mesially and filled in with thin, transparent chitinous lamella, and how this lamella has gradually thickened, become opaque and developed denticulae along its masticatory margin to end as the superficially commonplace border of an ordinary-appearing triangular mandible.

The same two complexes are also remarkable in both having produced species with thin, complicated and involuted lamelliform structures on the sides of the pedicellar nodes. While universal as "spongiform appendages" in the *Strumigenys* complex, these convergent structures appear only in the more derivative genera of the *Epopostruma* complex.

After many such modifications had appeared among the dacetines, something happened to the arboreal forms; probably they were pushed nearly out of existence by more efficient competitors among the ants or other insect groups. *Daceton* remains to show us what a relict of this probably once-powerful fauna is like. Unfortunately, although *Daceton* is common and conspicuous in the Amazon-Orinoco Basins and has been observed and collected on many occasions, no one seems to have recorded its feeding habits or other important ethological points of great interest. The most suggestive observation is that of Mann (1916):

"There were several colonies of *Daceton armigerum* in the grounds of the Zoological Garden at Pará, where workers were very often seen on the fences and trees. At Itacoatiara I found a very large colony nesting in a hollow standing tree."

Otherwise, *Daceton* is of great interest historically, for it so happens that it was the first dacetine ant to be described. Latreille gave the single species the name "*Formica armigera*" in 1802. No other species was reported until 1853, when Frederick Smith described *Orectognathus antennatus* from New Zealand. The much smaller European and North American species of *Strumigenys*, *Smithistruma*, *Trichoscapa*, etc. had gone unnoticed all this time, and most of them were to remain unknown for several decades even at that late date.

The history of the dacetines has been largely one of scattered descriptions, with no realistic revision and little critical appraisal of any of the described species. Therefore, the tribe was exceedingly ripe (not to say overripe) for a major revisionary effort. The task is so large that it can be effectively attempted by this author only in parts. The work recorded in this revision to date includes about one-third of the necessary changes, though most of the remainder is in various stages of completion. It is thought that at least the generic arrangement presented will survive major changes for a considerable time.

#### Reference Collections of Dacetini

The present revision is based on direct examination of a majority of the types of older species, made possible through the kindness and patience of

curators or owners of collections all over the world. In cases where unique types could not be sent, I was almost always able to obtain camera lucida drawings and other critical information enabling me to place questionable forms with satisfactory accuracy. Only because of such admirable cooperation is it now possible to attempt a taxonomic treatment of the entire world fauna.

Before the present time, no single collection has held more than a fraction of the described dacetine species. The scattering of types has been very wide, a fact that has added considerably to the difficulty of assembling this work on a world basis. Due to the former unavailability of types and the extremely confused state of the literature, many collections, particularly those in the New World, have accumulated surprisingly large stores of undetermined material.

New species among this material have come to light with such unexpected abundance as to seriously hamper the progress of the work toward its original revisionary goal. This is particularly true of the unworked collections of the Museum of Comparative Zoology, the United States National Museum, and of Dr. W. M. Mann.

The new species have proven helpful, however, in providing a basis for exchange with Old World collections and also for dividing New World collections in a mutually more useful way.

The extensive exchanges carried on in the course of the revision have raised the general quality of most dacetine collections in both hemispheres to a degree which, it is hoped, will permit the interested specialist to identify at least the commoner species from specimens deposited within reasonable travel distance.

The Museum of Comparative Zoology has been selected as the key place of deposit, chiefly because it has furnished the largest amount of exchange material from any single collection, but also because it already contained a nucleus of types and other identified material at least equal to that of any other collection in the world.

Due to the fact that series studied were so often limited in numbers, apportionment in outgoing exchange was necessarily made as nearly equivalent to the material received as was possible. Under these circumstances, the possibilities of building a personal reference collection for myself were so limited that I have considered it more logical to forego efforts in this direction.

In the list following, I have set down the principal collections containing taxonomically important dacetine series, together with the name of the owner or institution of deposit and the abbreviations for the same used in the body of this work. The abbreviations [in brackets], where used with descriptions, denote specimens on deposit.

Academy of Natural Sciences, Philadelphia, Pennsylvania—[ANS]. Agricultural Research Institute, Pretoria, Union of South Africa—[ARISA]. American Museum of Natural History, New York City—[AMNH]. Dr. George Arnold (personal) and in National Museum of Southern Rhodesia, Bulawayo, Southern Rhodesia—[Arnold Coll.]. Father Thomáz Borgmeier, Rio de Janeiro, Brazil—[Borgmeier Coll.]. British Museum (Natural History), London—[BMNH]. California Academy of Sciences, San Francisco, California—[CAS]. Chicago Natural History Museum, Chicago, Illinois—[CNHM]. Mr. John Clark, Melbourne, Victoria, Australia—[Clark Coll.]. Sr. Mario Consani, Florence, Italy—[Consani Coll.]. Emery Collection, Museo Civico di Storia Naturale, Genoa, Italy—[Emery Coll.]. Forel Collection, Musée d'Histoire Naturelle, Geneva, Switzerland—[Forel Coll.]. Finzi Collection: deposited in Museum of Compara-

tive Zoology, which see. Hungarian National Museum, Budapest—[Hung. NM]. Illinois State Natural History Survey, Urbana, Illinois—[INHS]. Dr. W. M. Mann, National Zoological Park, Washington, D. C.; personal collection, kept in U. S. National Museum, which see—[Mann Coll.] Mayr Collection, Naturhistorisches Museum, Vienna—[Mayr Coll.]. Musée du Congo Belge, Tervuren, Belgium—[MCB]. Museum of Comparative Zoology at Harvard College, Cambridge, Massachusetts, U. S. A.—[MCZ]. Easily the largest and most important single existing aggregation of dacetine material. Includes the Wheeler Collection and several substantial additions, among them many types of Mann, Weber, Forel, Emery, Mayr, Santschi, Menozzi, M. R. Smith, the Wessons, Arnold, Borgmeier, the present author and others. The collection of the late Bruno Finzi was added during 1950. Naturhistorisches Museum, Hamburg, Germany—[NM Hamburg]. The dacetines on deposit here may have been destroyed by bombing during the war, though this is at present unconfirmed. Roger Collection, see Zoologisches Museum der Universität, Berlin, Santschi Collection, Basler Naturhistorisches Museum, Basle, Switzerland—[Santschi Coll.]. Stitz Collection, see Zoologisches Museum der Universität, Berlin. United States National Museum, Washington, D. C.—[USNM]. Dr. Neal A. Weber, Swarthmore College, Swarthmore, Pennsylvania—[Weber Coll.]. Wesson Collection, see Museum of Comparative Zoology. Wheeler Collection, see Museum of Comparative Zoology. Dr. Keizō Yasumatsu, University of Kyushu, Fukuoka, Japan—[Yasumatsu Coll.]. Zoologisch Museum en Laboratorium, Buitenzorg (Bogor), Indonesia—[ZMLB]. Zoologisches Museum der Universität, Berlin, Germany—[ZMZB].

#### ACKNOWLEDGEMENTS

In the list which follows, I have tried to mention the names of all the individuals who have made this work possible, either through loan, gift, or exchange of material (m), or through other sorts of assistance (a) that cannot be detailed here. Where the aid has involved specimens or information concerning specimens from one of the major collections listed above, the abbreviation for the collection follows the individual's name; unless otherwise stated, the individual is associated through curatorship or ownership or otherwise closely with the particular collection concerned.

Miss Mary E. Amstutz, Ashland, Ohio (m). Dr. George Arnold (Arnold Coll.; m, a). Dr. Pierre Basilewsky (MCB; m). Dr. J. C. Bequaert (MCZ; m, a). Dr. F. Bernard, Université Alger (Santschi Coll.; a). Dr. H. Bischoff (ZMB; a). Dr. F. Bonet, Escuela Nacional de Ciencias Biológicas, Mexico City (m). Father Thomas Borgmeier, OFM (Borgmeier Coll.; m, a). Professor F. M. Carpenter, Harvard University (a). Dr. J. W. Chapman, Silliman Institute, Dumaguete, Philippine Is. (m). Mr. F. Y. Cheng, Harvard University (m, a). Mr. Kenneth Christiansen, Harvard University (m, a). Mr. John Clark (Clark Coll.; m, a). Dr. A. C. Cole, Jr.; University of Tennessee, Knoxville (m, a). Sr. Mario Consani (Consani Coll.; m, a). Dr. K. W. Cooper, Princeton University (m). Dr. W. S. Creighton, College of the City of New York (m, a). Dr. A. Diakanoff (ZMLB; m). Miss Ruth Dunn, Harvard University (a). Mr. H. St. J. K. Donisthorpe (BMNH; m, a). Mr. H. S. Dybas (CNHM; m). Dr. W. Eichler, Parasitologisches Institut der Universität Leipzig (a). Dr. J. C. Faure (ARISA; m). Dr. Charles Ferrière (Forel Coll.; m, a). Dr. S. W. Frost, The Pennsylvania State College (m, a). Dr. C. J. Goodnight, Purdue University (m). Dr. Delfa Guiglia (Emery Coll.; m). Dr. E. Handschin (Santschi Coll.; a). Dr. E. M. Hering (ZMB, a). Lt. J. W. Jones, Jr., U. S. A. F. (m, a). Father W. W. Kempf, OFM, Cornell University (a). Dr. C. H. Kennedy, Ohio State University (m). Dr. Nicolás Kusnezov, Instituto Miguel Lillo, Tucuman, R. Argentina (m). Sr. Frederico Lane, Secretariat of Agriculture, São Paulo, Brazil (m). Dr. M. A. Lieftinck (ZMLB). Mr. Arthur Loveridge (MCZ; m, a). Father John McAreavey, SJ, Xavier College, Melbourne, Australia (m). Dr. W. M. Mann (Mann Coll.; m, a). Mr. G. E. J. Nixon, Imperial Institute of Entomology, London (BMNH; a). Mr. W. L. Nutting, Harvard University (a). Dr. Kikumaro Okano, Numazu, Japan (m, a). Dr. Orlando Park, Northwestern University (m). Mr. D. W. Pfitzer, University of Tennessee, Knoxville (m). Dr. Bruno Pittioni (Mayr Coll.; m, a). Mr. J. A. G. Rehn (ANS; m, a). Dr. E. S. Ross (CAS; a). Father Jerome Rupprecht, St. Vincent Archabbey, Latrobe Pennsylvania (m). Dr. George Salt, Kings College, Cambridge, England (m). Mr. H. F. Schwarz (AMNH; m). Dr. M. R. Smith (USNM; Mann Coll.; m, a). Mr. L. J.

Stannard (INHS; m, a). Dr. A. Stärcke, Den Dolder, Netherlands (m). Dr. Mary Talbot, Lindenwood College, St. Charles, Missouri (m, a). Mr. Ernest Taylor, Hope Department of Entomology, University Museum, Oxford, England (m). Mr. B. D. Valentine, University of Alabama (m). Mr. Arnold Van Pelt, University of Florida (m). Dr. N. A. Weber (Weber Coll.; m, a). Mr. F. G. Werner, Harvard University (m, a). Dr. L. G. Wesson, New York University College of Medicine (m, a). Mr. R. G. Wesson, San Jose, Costa Rica (m). Dr. G. C. Wheeler, University of North Dakota (m). Mr. E. O. Wilson, University of Alabama (m). Mr. John Woodland, Harvard University (a). Dr. D. L. Wray, North Carolina Department of Agriculture, Raleigh (m). Dr. Keizō Yasumatsu (Yasumatsu Coll.; m, a).

During the three years this work has taken, I have benefitted enormously from the everlastingly patient and wise counsel of my thesis advisor, Professor F. M. Carpenter. He would be the last to claim a share of the credit for any small success this work may enjoy, but if credit there is, a large part of it is certainly his.

### Measurements and Proportions

In general, the dacetine species show very strictly limited variation in dimensions and proportions compared to other ants. The total length, degree of elongation of head, length of mandibles, etc. can be reduced to numerical values of high constancy, and in this revision the numerical values are treated as of the very first importance. Unfortunately, former authors either disregarded dimensions and proportions entirely, or else gave such vague and often patently inaccurate values that I have had to ignore most former statements concerning them except as they might be used as the roughest sort of taxonomic clues. I have thus had laid out for me the enormous task of measuring and calculating proportions not only for the new species described during the course of this work, but also for the entire array of previously described forms.

In most cases, I have been able to see types or other reliable material of the older forms. Data based upon these naturally vary in usefulness with the number of specimens measured. In several cases where specimens were not available for study, published figures have allowed at least a rough estimate of proportions of head and mandibles. Estimates made from figures are, of course, subject to the errors made in the original sketch, and experience has shown that former authors were often none too careful in preserving accurately the proportions in their figures. About 8,000 specimens have been subjected to an average of 5 measurements each, so that over 40,000 actual measurements have been made in the three years covered by this work.

In obtaining these measurements, it was early obvious that more rapid and accurate methods than those conventionally used would have to be devised. The following apparatus was used with very good results: (1) A wide-field binocular (stereoscopic) microscope, objectives powered 1.7X, 4.8X, 6.8X; oculars powered 12.5X, 25X, 30X. The 4.8X objective with the 12.5X ocular, giving a magnification of 60X, was used almost constantly in measuring. (2) An ordinary squared ocular disc, such as is commonly used in making sketches. A disc was chosen of such calibration that, with the 4.8X objective, each square of the disc marked off a square 0.2 by 0.2 mm. on the object as viewed. This choice of calibration overcame a difficulty which would have made the enormous number of calculations virtually impossible, since the value in millimeters could be calculated simply by multiplying by a factor of 0.2 the observed measurement in ocular disc graduations. The

standard ocular micrometer was rejected at the beginning of the work, since, although its graduations were finer, the counting of units proved altogether too slow and open to error by miscounting. The unit of 0.2 mm. could be subdivided by estimation to an accuracy of the order of  $1/20$  of a disc interval, or to within 0.01 mm. Actually, estimation by the practiced eye proved to be capable of even greater accuracy, as was shown by subsequent checking of selected measurements. In any event, the error due to inaccuracy of estimating the scale was less than that due to differences in positioning and other factors such as indistinct margins under dense pilosity, etc. If, as is usual with squared discs, one of the squares is further subdivided, the doubtful estimates may be checked with greater accuracy. A specially made disc with graduations just half as broad as those on my disc would be ideal for such measurements, since not only would more accurate estimation of fractions be possible, but also the calculations would be reduced to a mere shift of the decimal point. Unfortunately, such a disc was not available for this work.

(3) A small manipulator consisting of base, horizontal axis with semi-circular arm, and, affixed to the arm, a disc rotating upon a second axis perpendicular to the first, this disc with a central aperture for cork or other material into which the insect pin is inserted. With this instrument one can rotate the insect slowly under the microscope until reaching the most advantageous viewing angle, upon which the position will be held firmly until a change is desired. Operation is manual. The base of the manipulator was placed in (4) a standard mechanical stage fixed to the ordinary glass stage of the microscope. The mechanical stage afforded a rapid and accurate means of bringing the insect into exact juxtaposition with the graduations of the ocular micrometer.

The apparatus described is rather complicated in operation, since there are four separate controls to handle in addition to the focussing of the microscope and rotation of the ocular disc to the desired position for measurement. However, after a bit of preliminary fumbling, operation became second nature and went so much more rapidly and accurately than the conventional and very uncertain methods of measurement by adjusting and readjusting the insect pin in a stationary cork that the latter soon became unthinkable. A warning is here sounded to those who would identify *dacetines*, with or without this paper: unless already very well acquainted with the species of the tribe, the specialist will almost necessarily have to provide himself with an apparatus similar to that described above, or at least one operating with a like degree of ease and accuracy. Dimensions and proportions are quite necessarily used in specific and even generic determinations; a lesser degree of accuracy than that here specified will cause serious difficulties in obtaining a correct identification for almost any species.

Even with the best apparatus, there are certain other very important factors which must be taken into account when measuring *dacetines* (or any other ants). Positioning is the most important of these, and is involved with the further pertinent problem of what to measure. Various means have been suggested by entomologists for obtaining measurements that will be standard from one specimen to another as measured by anyone. The means seemingly most often used (though statements concerning it seldom accompany descrip-



tions) is plain visual judgment, although fillips such as "getting the two sides in the same plane or focus" are employed by some as qualifications to the judgment method. Such a method is far too crude for the present purposes.

The method of positioning which I have followed does not seem to have been set down very clearly in the entomological literature, although it is assumed that it has been tacitly followed by at least some former workers. The theoretical basis of the procedure rests upon the proposition that, given two definite limits separated by a distance to be measured under a microscope, the *maximum* distance that can be made to appear between the two limits as seen by one eye is the only really accurate standard measurement. This maximum measurement as a standard is apparent when a long, slender object, such as an antennal scape or a tibia is being measured, and I have no doubt that most entomologists consciously or unconsciously employ it. It is not so apparent, however, in dealing with thicker, broader objects like the head, and it is with such objects that standards of proper measurement are woefully lacking in ant taxonomy. Part of the difficulty has been that with the older methods of positioning, using only a stationary cork, it has been impossible to closely approach the critical maximum with any certainty. The manipulator eliminates most of this uncertainty because it may be rotated slowly and smoothly enough that, when turning through the point at which the critical maximum is reached, the actual advance and retreat of the dimension against the ocular grid may be watched in progress and stopped at the proper point. With a stationary cork, the position must be shifted by removing and reinserting the pin so that only a discontinuous change in apparent dimension is ordinarily possible.

Needless to say, the critical maximum measurement is used throughout this revision.

With the problem of positioning settled by the only practicable standard method, the question of what should be measured becomes acute. Part of the answer lies with that to the positioning problem, for it is obvious that if the greatest possible dimension that can be made to appear is the one measured, then the reference points must be the opposing extremities of the part examined. Even so, considerable qualification is necessary if actual measurements are to mean anything, since the position of the insect as it is mounted in death often raises difficulties.

As mounted on a point or card, the body of the ant is not usually fully extended along one axis. The head is often bent downward at an angle to the alitrunk, and the petiole, postpetiole and gaster usually are bent with respect to one another so as to form a sort of arch. A study of measurements given by past authors for dacetine ants shows that most of them gave only a "total length." While most descriptions do not so state, it appears that the mandibles were included in this length in the great majority of cases. In cases where unique types were involved, I have carefully remeasured some of these specimens in order to gain an idea of the methods used by various authors in making measurements. Without going into detail, I can state that the overall length of the ants has almost invariably been underestimated. This is due, in my opinion, to a measurement involving a single linear spread from the part of the ant which happened to be most anterior to that which hap-



pened to be most posterior on the particular specimen examined. Only by making a single linear measurement, ignoring the relative positions of the various parts of the insect, have I been able to come close to duplicating the values published in the older papers. Such a measurement is probably nearly always made from dorsal view, and utilizing this view it is entirely possible to get a measurement for specimen A, an insect happening to be larger but in a more compactly contorted position, that is smaller than the measurement for the actually smaller, but more extended specimen B.

It is obvious from this that older measurements are not at all comparable one against another. Furthermore, older authors did not consider the accuracy of the measurements to be important, and most of them followed the practice of stating the dimension to the nearest half or third of a millimeter. In the measurement of large ants, such considerations are not very important, chiefly because the percentage of error (compared with the method here recommended) varies under the old system inversely with the length of the insect. In the dacetines the error in older measurements (as compared to those given in the present work) may be as high as 50%. By this I mean that an ant measured in a former work to be "1½ mm." may, if carefully and fully stretched out, be found to measure as much as 2.25 mm. The chief objection to such measurements, which are presently seen to be extremely important in the dacetines, is not that they are consistently smaller than my own, but rather that they are so completely lacking in standard reference value. Every author followed his own idiosyncratic method of measurement, and none stated the method used; these measurements are valueless for present purposes except used indirectly as the crudest of indicators of overall dimensions.

While it is easy to damn completely the old methods, the devising of a practicable standard way of gaining comparable measurements is not so easy. Various authors, such as Arnoldi, Weber and other recent myrmecologists, have suggested measuring the greatest (diagonal) length of the "thorax" from the side view, since that is often the longest completely rigid section of the body. This measurement has been suggested chiefly to overcome the variability in the gaster, which in some ant genera may be greatly distended or strongly shrivelled according to the specimen and conditions of its preservation. I agree that this measurement is generally satisfactory, and I have used it throughout the revision as "Weber's length" or "WL." Weber has stated it clearly, with diagrams, in his paper on dimorphism in African *Oecophylla* (1946). I have discussed the qualifications used with regard to it farther below.

The original reason for the use of Weber's length does not apply very well in the dacetines, however, for in this tribe the gaster usually varies but little in size. I have considered it helpful to give a measurement expressing to some degree the overall length of the insect at its fullest linear extension. Although it may be doubted that such full extension ever is seen in mounted specimens, or even that it occurs in living individuals, the method I shall outline below seems to me the only way of accomplishing a general linear body measurement that will be comparable from one species to another.

This method entails the summation of a series of linear measurements made upon the rigid sections of the body as follows:

*Head length:* Critical maximum length of the head, measuring from a transverse through the posteriormost point or points along the posterior occipital border to a transverse through the anteriormost point or points on the anterior clypeal border. In order to avoid ambiguity, a start in the progressive positioning is arbitrarily set as the "conventional" full face or dorsal view. A position that gets too far from this would be of little use, but such a position short of an absolute ventral view of the head will not occur at the critical maximum dimension in any dacetine species known to me. One possible question is raised, however, by the presence of teeth or spines on the occiput in genera like *Microdaceton* and *Hexadaceton*. In these cases, where the teeth are small and often distinct, measurement should either exclude them completely (as in this revision), or if the situation is ambiguous because of the broadness of the teeth, then the decision as to whether they should be included in the total measurement of the head or not should be covered by a special statement of the method used. In the measurement of dacetine ants, the mandibles and other mouthparts are pointedly excluded from the dimensions for the head for obvious reasons of relative development and because the comparison of the linear dimensions of the head proper and the exposed portions of the mandibles furnishes one of the most important quantitative characters used in this work. The symbol used throughout this work for the linear longitudinal critical maximum measurement of the head, as qualified, is "HL."

*Exposed length of mandibles:* Due to the fact that the majority of dacetine species have relatively elongate mandibles, and because the differences in degree of elongation furnish important taxonomic characters, this dimension is measured separately. As arbitrarily defined here, the exposed mandibular length is not the critical maximum exposed length, but is the length of the mandibles, when closed, as viewed while the head is in the same viewing angle (with respect to the microscope) from which HL was first determined at its critical maximum. This is mentioned because the mandibles are often naturally tilted dorsad or ventrad from the principal axis of the head. The measurement is made in this plane of view from the transverse through the anteriormost point or points on the anterior clypeal border to the extreme apical point of the most advanced mandible. In practice, this measurement will vary a little more in a given series of specimens than will that for HL, since the mandibles are found closed in different ways and are retractile to a very slight degree. Where the mandibles are very short and more or less arched, as in some smithistrumiform genera, this measurement may vary proportionately more than in long-mandibulate genera; in such cases, its value is reduced. The symbol used in this work for the exposed mandibular length, as qualified, is "ML."

*Length of alitrunk:* This is the "Weber's length of thorax" referred to above. The alitrunk is here defined as the true thorax (i.e., the first three postcephalic or postgnathal segments of the body, or the three leg-bearing

segments of adult insects, as defined by various morphologists) plus the propodeum (i.e., the first segment of the true abdomen, in all clistogastran Hymenoptera included in the second major tagma of the body and fused with the true metanotum). In most myrmecological works, the second tagma of the body is wrongly called the "thorax" as a holdover from the early period when the propodeum plus the metanotum were thought to represent the metanotum in its entirety. Since the term "epinotum" was originally very vaguely defined by Emery, and since it has been used to mean propodeum plus metanotum in at least part of the subsequent literature, on several occasions by Emery himself, it should be rejected in favor of the earlier and more generally-used term for this typical clistogastran structure, "propodeum."

In the dacetine ants, the pronotum is usually marked off from the "neck" by a curved transverse dorsal margin. When present, the anteriormost point reached by the margin usually is even or nearly even, seen from a directly lateral view, with the posteriormost level reached by the occipital lobes. For this reason, the pronotal border makes a very convenient reference point in measuring the alitrunk. In the rare cases where this margin is absent or indistinct, measurement is made from the base of the anterior pronotal slope, which in all such cases coincides very well with the point of juncture of the "neck." In a few cases, such as in *Strumigenys* of the *chyzeri* group, the occipital lobes project backward so far as to overlap the anterior portion of the pronotum. In such species, no change is made in the anterior reference point for the measurement of the alitrunk, but an account is taken of the overlap to be stated after the figures given for the general linear dimension of the body. The main point to be observed in measurement, I think, is that care should be taken to state the actual situation in all exceptional cases. In a tribe as large and diverse as the Dacetini, no blanket statement can hope to cover every single structural aberration.

The posterior reference point is taken as the posteriormost extremity of the small lobe at the so-called "metasternal angle" of the posteroventral alitrunk. One of these small lobes projects posteriorly to a slight degree on each side of the point of articulation of the petiolar peduncle, each is more or less closely associated with the metapleural gland housing, and if the view is perpendicular to the sagittal plane of the alitrunk, only the one on the side toward the observer should be visible. This point, the extremity of the metapleural lobe, is the posteriormost point reached by the alitrunk on either side if the very variable propodeal teeth and infradental lamellae be ignored.

When the insect is held in such a position that the sagittal plane of the alitrunk is perpendicular to the axis of view, the measurement taken is along a straight "diagonal" connecting the anterior pronotal margin with the posterior extremity of the metapleural lobe. This measurement of the alitrunk, as qualified above, is indicated by the symbol "WL" throughout the work.

*Length of petiole:* In the usual position assumed by dacetines as mounted, the petiole is at an angle with the principal axes of both the alitrunk and the postpetiole-gaster. It must therefore be measured separately. Measurement from lateral view is easier and more accurate; the visible length along the

natural axis of the segment, limited anteriorly by the posteriormost point of the visible metapleural lobe and posteriorly by the articulation with the postpetiole, is the most logical distance to measure. Since the petiole is normally a small segment, and since the only use to which I have put its measurement is in arriving at a more accurate general linear measurement for the body, small errors may be made in the measurement of this segment with negligible effect on the total dimension. This measurement has not been given except as a part of the general total for body length, so no symbol is required.

*Length of postpetiole and gaster:* The articulation between the postpetiole and gaster is limited in freedom of motion, and for this reason and because the postpetiole is short and of nearly the same dimension in either direction as seen in lateral view, only one linear measurement is necessary for these two parts in most dacetines. The position of view is a perpendicular to the sagittal plane of the parts in question, and the reference points are the imaginary center of the point of articulation between petiole and postpetiole and the posterior extremity of the gastric apex, excluding the sting or other parts obviously extruded. In the case of retractile male genitalia or other exceptions that may be encountered, a special statement of the situation is made.

Since the length of postpetiole and gaster is given only as a part of the total linear body measurement, no special symbol is required.

*General linear body measurement or "total length":* This is the sum of all the linear measurements discussed above, or  $ML + HL + WL + \text{length of petiole} + \text{length of postpetiole and gaster}$ . It must be stressed that this is a synthetic figure, possibly representing a length different from that produced by any position the ant might assume during life. It is felt, however, that no other means of obtaining measurements strictly comparable from specimen to specimen and with the necessary degree of accuracy has proven satisfactory. The objection that the measurements required are too many and too tedious for ordinary work will not hold, for with the proper apparatus as outlined above, the measuring may be done with surprising rapidity and accuracy. The symbol used throughout this work for the general linear body measurement is "TL."

*Cephalic index:* The critical maximum width of the head expressed as a percentage of HL, or  $HW/HL \cdot 100$ . The critical maximum head width in the great majority of the dacetines comes in the region of the occipital lobes. The measurement presents few difficulties. Occasionally, the pilosity of the occipital lobes obscures the borders, making it difficult to see the actual limits of the head; this can be overcome by reflecting the light from a white surface beneath the specimen so as to outline the head by contrast. The cephalic index is best computed from the raw data in terms of ocular grid units; this cuts down the error of calculation. The cephalic index is indicated by the symbol "CI."

*Mandibulo-cephalic index:* Exposed length of mandibles expressed as a percentage of HL, or  $ML/HL \cdot 100$ . Since both of the measurements needed

are normally made in any case, this index is simply a matter of calculation. In *Smithistruma* species, where the mandibles are short and vary somewhat in ML due to retraction, etc., the length of the mandibles is best expressed in terms of the index, and no absolute measurement is given. The mandibulo-cephalic index is indicated by the symbol "MI."

*Index of cephalic depression:* The greatest thickness of the head, in a direction perpendicular to the plane determined by the measurement of HL and HW, expressed as a percentage of HL. This index is open to slightly greater error of measurement than are others, and its use has been restricted mostly to cases where differences in cephalic depression between related species are quite distinct, or where the depression is extreme. The index of cephalic depression is indicated by the symbol "ICD."

*Other measurements:* I have attempted to put many other lesser measurements and proportions on some kind of a numerical basis, and I believe that these will be self-explanatory where found in descriptions. The letter "L" stands for critical maximum length, and the letter "W" for critical maximum width.

*Error of measurement and calculation:* Error in measurement must be kept to an absolute minimum if indices are to be calculated from the values, since otherwise the error may be so greatly multiplied in calculation that much of the significance of the final value will be lost. Error is caused by the limits of accuracy of the ocular grid, by failure to achieve the precise critical maximum positioning, by ambiguity of borders or other limits as seen on the insect, by lighting effects or other illusion, and by bias on the part of the observer. It is possible, of course, to determine the amount of error that may be expected in each size- or shape-class in the tribe. This has been done carefully for the measurements involving the head and mandibles, and more roughly for other measurements. Six specimens, representing forms as widely different in size and shape of head and mandibles as could be found in the tribe, were measured by the observer (myself) repeatedly at intervals great enough to allow the previous measurements to slip from possible recall. After ten such series of measurements, the values for each measurement were averaged, and the most extreme (high and low) deviations were considered as the maximum amount of error based on the average (mean). Except for one very gross error, which proved to be due to a lapsus, the differences were very small. In no case (except the one mentioned) was the amount of error greater than .01 mm., and in 81% of the measurements, the error was less than .005 mm. The errors were naturally more serious in the smaller measurements. As a final check, CI and MI were determined in random specimens of all shapes and sizes. The error here was never more than 2; in nearly 75% of cases, it was not more than 1. Several specimens checked by other observers agreed with my average values within the same error. It must be mentioned that all indices were calculated directly from the raw measurements in terms of ocular grid units, and not from the rounded-off millimeter values.

I shall present here a key to the symbols used in the text, their rough meanings, and their rough maximum errors:

Symbol	Measurement or proportion	Given in	Rough maximum error
TL	General linear body measurement (see qualifications).	mm.	$\pm .05$ mm. (?)
HL	Critical maximum length of head proper (see qualifications).	mm.	$\pm .01$ mm (usually less)
ML	Exposed length of mandibles (see qualifications).	mm.	$\pm .01$ mm (usually less)
WL	Weber's length of alitrunk (see qualifications and Weber, loc. cit.)	mm.	$\pm .01$ mm. (?)
CI	Cephalic Index (Critical maximum head width/HL $\cdot 100$ )	units	$\pm 1$
MI	Mandibulo-cephalic index (ML/HL $\cdot 100$ )	units	$\pm 1$
ICD	Index of cephalic depression (Maximum head depth/HL $\cdot 100$ )	units	$\pm 2$

Certain of the errors differ from those expressed in earlier papers, but the present ones are based on a larger number of observations.

The standard measurements and proportions are usually stated in the descriptions in the order given above. In cases where a very large amount of material has been reviewed, the range of variation shown by the great majority of individuals of the species may be placed in parentheses after the full statement of range in order to show the usual dimensions that can be expected.

### Statistical Treatment

During the early stages of this work, a great deal of experimentation was carried out with elementary statistical procedures. This experimentation was limited in application to forms of which material from a large enough number of different nests was available. In certain cases, such as that of the supposed variants of *Strumigenys louisianae*, it could be shown statistically that there was no significant difference between the colony-series tested. However, the same lack of significant difference was shown in the broad overlapping of the dimensions and proportions themselves. Since a significant difference of means in any measurable character shown by two colony-series would not necessarily show that the two series belonged to different species or races anyway, it appears obvious that statistical treatment in the present stage of dacetine taxonomy can offer no significant evidence that cannot be gained in easier and more obvious ways. When we finally come to the fine study of geographical variation, statistics may find a very useful application in confirming the existence of definable but obscure races and species.

Procedures for determining degrees of correlation between the numerically expressible characters found on the bodies of individual ants have a very useful application, however, in determining functional relationships between parts and also in demonstrating clearly the degree of polymorphism evidenced by

given colony-series. Parts of the revision in which such procedures can be used to advantage are still in progress, and will not be reported upon here. For the convenience of future workers who may care to use them biometricaly, I have saved the majority of my raw measurements on rough work-sheets, and I will make them available to anyone who shows evidence of using them for a serious and worth-while purpose.

### Strumigenys Complex

A large assemblage of genera and species, worldwide in temperate and tropical regions. The complex may be divided into two subcomplexes, one "long-mandibulate" (strumigeniform genera) and the other "short-mandibulate" (smithistrumiform genera). This division is probably artificial, at least in part, since the phylogenetic relationships of all the genera are by no means evident. As has been stated in the introduction, the strumigeniform mandible is considered the primitive type in the entire tribe; it is almost certainly the ancestral mandibular form in the *Strumigenys* complex. Probably the short, serially-denticulate mandible has arisen from the elongate, apically furcate form on two or more occasions, although this is not clear at present. In at least one genus, the process seems to have reversed itself, for *Dorisidris* appears to be little more than a *Glamyromyrmex* with secondarily lengthened, apically furcate mandibles.

In the strumigeniform genera, I would place *Strumigenys*, including the two subgenera, *Labidogenys* Roger and *Pyramica* Roger, and *Neostruma* Brown. *Quadristruma* also falls here.

The smithistrumiform subcomplex contains quite a few genera, but most of these are monotypic or contain very few species:

<i>Borgmeierita</i> new genus	<i>Pentastruma</i> Forel
<i>Codiomyrmex</i> Wheeler	<i>Serrastruma</i> Brown
<i>Codioxenus</i> Santschi	<i>Smithistruma</i> Brown
<i>Dorisidris</i> Brown	<i>s. str.</i>
<i>Epitritus</i> Emery	<i>Platysturma</i> new subgenus
<i>Glamyromyrmex</i> Wheeler	<i>Wessonistruma</i> Brown
<i>s. str.</i>	<i>Tingimymex</i> Mann
<i>Chelystruma</i> Brown	<i>Trichoscapa</i> Emery
<i>Kyidris</i> Brown	<i>Weberistruma</i> Brown
<i>Miccostruma</i> Brown	

In addition to these, there is a single specimen in my possession, sent by Dr. Kikumaro Okano from Japan, representing a clear-cut new genus intermediate between *Epitritus* and *Smithisthuma* (*Wessonistruma*). Dr. Okano has intended to describe this form as a species of *Strumigenys*, but I hope that further study has convinced him of its distinctness from all previously described genera.

The genera *Quadristruma*, *Codioxenus*, *Dorisidris*, *Epitritus*, *Glamyromyrmex*, *Miccostruma*, *Pentastruma*, *Tingimymex* (see fig. 34), and *Trichoscapa* have been dealt with in published parts of this revision (1948, 1949) or in one part now in press. The remaining genera will be treated here or in parts of the revision to be published within a short time. The final sections will deal with *Strumigenys*, which contains more species than do all the rest of the dacetine genera combined.



SPECIATION IN THE *STRUMIGENYS* COMPLEX

The present study has included an intensive examination of far more dacetine material than has ever before been gathered together in one place. I may make one generalization on the basis of this material, it is this: at present there appear to be no populations in the tribe which can confidently be termed geographic races. The subspecies erected by former authors were found to be absolute synonyms of already existing species or else independent species in their own right. After careful consideration of each case on its own merits, all varieties among the dacetines have been synonymized, except for a very few which are raised to species rank because of purely nomenclatorial technicalities.

Compared to other ant groups of comparable size, dacetine subspecies and varieties were not commonly described by the older authors, a fact concerning this tribe which supports my finding that few if any races exist. Of course, it may be that among the great mass of dacetine species known only from one or a handful of collections there exist at least a few geographical races. The commoner, more widely distributed, and therefore better-collected species might be the ones most expected to throw territorial variants. In well-collected species like *Strumigenys louisianae* Roger, *S. biolleyi* Forel, and *S. elongata* Roger, there is, to be sure, considerable variation in size, proportions, color and other characters, but this variation appears more or less at random throughout the range. Several of these species were treated statistically, but the results so uniformly showed lack of a tendency toward geographical apportionment of quantitative characters that the technique was abandoned. The same widespread, variable species, however, were found in all cases to be distinct by more than one clearcut character from the most closely related species, and little difficulty was experienced in determining them once the synonymy was fully straightened out. The species of dacetine ants have in general proven much more distinct than are those of other similarly large ant tribes.

If the above considerations hold true after collections of dacetine species become more complete, there could arise at least two explanations:

1. The dacetines are a very old group, now contracting their range and existing for the most part as specialized relicts.
2. The dacetines form very small populations in highly specialized niches, and therefore, according to some biological theory, are more likely to form numerous, quickly isolated species.

Neither of these generalizations really explains very much. The first might be accepted by some, but recent evidence which has been accumulating shows that species of several widely differing genera, particularly in the *Strumigenys* complex, are neither uncommon nor very old, and that they are surprisingly often able to master new environments as efficient tramp species. The increasing use of the Berlese funnel reveals that the dacetines are not limited solely to moist forest habitats, for several species have been found in open areas which originally lacked forest cover.

The present study cannot hope to solve problems of speciation in the group, but it certainly suggests that the dacetines do not form species in exact-

ly the same way as do some old and widespread genera like, for example, *Monomorium*.

My definition of a species does not include the possibility of the occurrence of genetically isolated populations based on aberrant multiplication of chromosome numbers or on complete parthenogenesis, since neither phenomenon has been satisfactorily demonstrated in the ants. Instead, I follow three simple conditions which I believe are essentially those demanded by most modern zoological taxonomists.

1. The species is a population inhabiting a given territory.
2. This population is distinguished by possessing one or more characters different from those of other populations. Characters are morphological in the broadest sense, and may manifest themselves only in overt physiological or behavioral terms, or else may be completely undetected at present. In present-day formicid taxonomy gross external and a few internal morphological features are practically the only ones in which variation has been recorded sufficiently well to permit their use.
3. At least one of the characters present in the population (not necessarily the one most useful in identification) must act to prevent interchange of genes with another population when such interchange would result in a hybrid population able to maintain itself indefinitely in nature.

All of my species, at least theoretically, must satisfy all three of these requirements. According to modern theory, the only recognizable infraspecific category completely acceptable as a distinct population for taxonomic purposes is the geographical race, here called subspecies. The subspecific population must, to be distinguishable, satisfy the first two requirements above, but not the third, and it must therefore inhabit a territory distinct in the main from that occupied by other subspecific populations of the same species. In other words, subspecies must exhibit a high degree of allopatry behind at least partial barriers to genetic interchange. Where the two populations meet and overlap, a hybrid belt can and will occur. Reasonable proof of two subspecific populations would therefore consist, in cases where the two populations are contiguous in range, of convincing evidence of the *broad* allopatry of a character or characters and also of the intergradation of these characters along the line of territorial contiguity. In this concept, the various ecological and physiological races postulated by many writers, as well as "nest varieties" among ants, may not be accepted as valid subspecies.

A subject which requires special mention in connection with taxonomic concepts is that arising from the dissemination of certain relatively highly adaptable ant species through commerce. As I show in my preliminary revision (1948, pp. 113-114), several dacetine species have displayed surprising ability to act as transoceanic tramps. In genera such as *Trichoscapa* Emery and *Quadristruma* Brown, I have synonymized several forms because I believe that they are represented by migrant populations established within historic times. In these and many other ant genera which include tramp species, endless names have been set up on a morphologically unsound basis, since supposed differentiating characters are given undue weight in correspondence with the degree of presumed geographic "isolation" from similar populations.

Where thoroughly known, the parent stocks of the migrants usually have shown a degree of variation which embraces all the features of the derived populations. The conditions of the migration, however, are such as to restrict greatly the number of fertile females arriving on a given new shore at a given time, and this implies the establishment of a more restricted and therefore more homogeneous population in the new home than in the old.

Often the degree of variation of the parent stock within the original range is poorly known, hence the description of such forms as the *Myrmica laevinodis* variants from three separate seaport areas on the east coast of North America. I submit that such variants, providing that they are recognized as immigrant tramps, should be ruthlessly thrown into synonymy, since even if they stemmed from different subspecies of the parent species, the probability that each form could remain isolated from contact with genes of forms with which it is interfertile is very low. The distinct seeds of different populations entering at different points on the coast of a new insular or continental area can be expected to exchange genes with each other eventually through the agency of strays (reaching one area from another by means of commerce, winds or coastal currents) and also by expansion of their range until they are both permanent inhabitants of the same territory. Genes can also be expected to reach the new coast from the original range at any later time. The net effect of all this interchange, which can be expected to accelerate with the more rapid and therefore less rigorous conditions of transport, will be a tendency for the total population in the new territory to gain all or many of the genes shown by the original stock and thus become more and more similar to the latter in total variation. Until intensive biological studies of these forms are initiated, it would appear best to eliminate the taxonomic clutter of varieties and subspecies based on them. This is easily done in the Dacetini, where variation within a species is not often so great as in genera like *Myrmica*.

The nest varieties which most writers have insisted on naming to the extreme confusion of ant taxonomy are here firmly rejected as taxonomic entities.

Adequate characterizations of gross external morphology must be prepared for certain older species where few now exist. A start must be made in summarizing distributional and biological data, now scarcely existing for most species, and in preparing tables to assist in the identification. The present revision attempts some of these projects for the world fauna. It is not to be considered a hand manual for the layman, or even for the general entomologist, because the number of unknown species certainly exceeds that which I here recognize. The best that I can offer is a reasonably logical framework for the addition of knowledge of the dacetines by myrmecologists; it is hoped that the framework has been built broadly enough to survive the onslaught of new species which will surely come during the next decade, novelties which will inevitably make this work obsolete.

#### HISTORICAL NOTES

The history of the *Strumigenys* complex before my preliminary revision of 1948 is largely the history of the portmanteau genus *Strumigenys*. The same men who so eagerly engaged the difficult task of splitting larger genera like

*Camponotus*, *Crematogaster*, and *Aphaenogaster* often with very uncertain results had somehow overlooked the much more obvious generic and subgeneric entities gathered in *Strumigenys*. In 1922, Emery used the *Genera Insectorum* to crystallize the body of opinion which had slowly groped toward a division of the genus into two groups, one with "long" mandibles, the other with "short" mandibles. The final word of Emery was a vaguely defined division into two subgenera; the names decided upon, respectively, were *Strumigenys sensu stricto* and *Cephaloxys*. Emery also showed his extreme conservatism in regard to the group by placing Wheeler's *Codiomyrmex* as a third subgenus of *Strumigenys*, an act which failed to win recognition from American workers.

The division into two major subgenera continued until 1948, though M. R. Smith showed in 1943 that the name *Cephaloxys* was preoccupied and replaced it by the next available name, *Trichoscapa* Emery. In my revision of 1948, *Strumigenys* was separated into several large and small generic and subgeneric groups, and with further alterations in 1949, the generic and subgeneric grouping became that which I have outlined in a foregoing section.

The descriptions of the species which made up the old genus *Strumigenys* are extremely widely scattered in the literature, and their quality is in most cases poor. With certain exceptions, the characterizations and comparisons of Mayr and Emery are the best published during the earlier days, though Mayr gave no figures, and the figures by Emery are often untrustworthy. The species of Frederick Smith and Forel are generally poorly described and not or inadequately figured. Among modern works on the group, that of M. R. Smith is easily the best and most useful, though limited to the New World fauna. Work done by other authors since 1900 has been mixed in quality, though mostly on the poor side, and it is largely during this time that the inexcusable number of synonyms has been built up. Most of the synonymy is due to carelessness in checking descriptions in the genus before describing novelties, and to previous hastily done, incomplete descriptions and misleading figures. On the whole, the taxonomy of the dacetines may be said to have been very poorly executed, even considering the fact that much of it was pioneering work in a relatively little-known field.

There has been published no real revision of the tribe or any important part thereof, although M. R. Smith's 1931 paper and several of his smaller subsequent ones did provide competent reviews of limited groups of species from the New World fauna, complete with figures and keys and based on actual material. The Wessons extended this conspectus for the North American species in 1939. Other published keys have either been based in large part upon original descriptions (often worse than worthless for purposes of identification) or else cover so few species that they are not very useful to the prospective reviser.

#### CODIOMYRMEX Wheeler

*Codiomyrmex* Wheeler, 1916, Bull. Mus. Comp. Zool. Harvard 60:326-327. *Strumigenys* (*Codiomyrmex*) Emery, 1922, Gen. Ins. Fasc. 174:325. *Codiomyrmex* Brown, 1948, Trans. Amer. Ent. Soc. 74:114-115.

*Worker*: Size small. Resembles *Smithistruma*, but the head relatively shorter, thicker and broader, in this respect resembling more closely the species

*Glamyromyrmex* and *Borgmeierita*. Antenna short and rather thick, the proportions as in *Glamyromyrmex*. Mandibles robust, broad and dorsally convex; basal lamella present, apical series of teeth strong and acute, reduced in number in one of the species. Essentially, the mandibular structure is as in *Glamyromyrmex*. Ventrolateral borders of head terminating anteroventrally in a small tooth on each side, just behind the mandibular insertions, just as in some *Glamyromyrmex* species. Cephalic dorsum densely and rather coarsely punctate or rugulospunctate, remainder of body with sculpture largely effaced, smooth and shining. Pilosity distinct, abundant to very abundant, consisting of fine tapered hairs, long to moderately long, not reduced or appressed over most of body, and widely distributed. Color blackish- or dark reddish-brown.

*Genotype*: *Codiomyrmex thaxteri* Wheeler (monobasic).

As here considered, the genus contains only the two rare forms *thaxteri* and *loveridgei* new species. While these forms may ultimately be considered as representative of separate genera, the abundant details of structural agreement presently indicate that generic separation would be entirely premature. Whether or not they are generically distinct, it appears quite clear that these two species are very closely related; in view of their known distributions, this relationship is all the more strange. *Thaxteri* is known only from Trinidad, while *loveridgei* has been taken only on the high Nyika Plateau in British East Africa. Although it is entirely probable that more species related to *Codiomyrmex* will be collected in the next few decades, the chances are that these and other species of the group of genera related to *Glamyromyrmex* will all prove to be relict species of very distinctive character, isolated remnants of a diverse older fauna. Nothing is known of the habits, but it is assumed that the two present species lead a cryptobiotic existence in the soil or soil cover as predators of some small arthropods.

#### CODIOMYRMEX THAXTERI Wheeler

*Codiomyrmex thaxteri* Wheeler, 1916, Bull. Mus. Comp. Zool. Harvard 60:326-327, fig. 1, worker. *Strumigenys* (*Codiomyrmex*) *thaxteri* Emery, 1922, Gen. Ins. Fasc. 174:325. *Codiomyrmex thaxteri* Weber, 1934, Revista de Ent. 4:52. Brown, 1948, Trans. Amer. Ent. Soc. 74:115.

*Worker*: Wheeler's characterization and figure seem to be quite satisfactory, except for his statement of length, "nearly 2 mm." On remeasurement, the workers in the type series [MCZ cat. no. 9122; USNM] all proved to be well over 2.50 mm. in total length. An "average specimen" from the cotype series: TL 2.79, HL 0.65, WL 0.66, CI 86, MI 18; two other specimens from the same series scarcely differed by perceptible degree. Dentition of mandibles not ascertained by dissection, but appearing similar to that normal in *Smihistruma*; basal lamella and about 12 teeth present in the apical series. Color of cotypes at present deep ferruginous; gaster mahogany; legs and antennae lighter and more yellowish.

*Type locality*: Port of Spain, Trinidad, B. W. I. (R. Thaxter).

#### *Codiomyrmex loveridgei* new species

*Holotype worker*: TL 2.22, HL 0.53, WL 0.52, CI 73, MI 23. Clypeus 0.21 mm. wide. Considerably smaller than *thaxteri*, and with a narrower head and slightly less broad mandibles. Head seen from a directly dorsal position with straight posterior occipital border; lateral occipital borders rather weakly laterally expanded, gently rounded, anteriorly converging in such a way as to be very nearly continuous with the converging preocular laminae in outline. Dorsolateral borders of the head (frontal carinae) not

broadly expanded and convex over the antennal scrobes as in *thaxteri*, but the scrobes rather deep and well-marked in any case. Eyes very small, situated on the ventral scrobe borders a little behind the cephalic midlength. Clypeus triangular, slightly broader than long, anterior border broadly and feebly convex, lateral angles narrowly rounded; discal surface very gently convex in both directions. Ventral border of scrobe cariniform, ending anteroventrally in a small tooth just behind and below the mandibular insertions; in this respect similar to *thaxteri* and some species of *Glomyromyrmex*.

Antennal scape about 0.24 mm. long, of typical *Codiomyrmex-Glomyromyrmex* form, short, stout, basally gradually narrowed and extremely feebly sigmoidally curved. Funiculus 0.40 mm. long, the apical segment rather thick and occupying just about exactly half of the funicular length; segment IV broad, longer than II + III; I more slender, but subequal to IV in length; II about as broad as long; III slightly broader than long.

Mandibles thick, broad, somewhat arched and very convex dorsally, lateral margins gently curved. Apical border seen edge on (the mandibles are partly open) forming a nearly complete and perfect semicircle. Basal lamella large, erect, translucent, triangular in shape, slightly longer than wide at base, the apex narrowly rounded. The lamella is only partly covered by the clypeus when the mandibles are fully closed. Teeth of apical series 8 in number, following the basal lamella directly, without a diastema; the teeth all stout and acute, no. 1 small, 2 larger, 3 the largest by a slight amount, 4 and 5 successively shorter, 6 and 7 small, preapical in position, their bases fused together and with the base of the apical tooth, which is approximately equal to them in size.

Alitrunk much as in Nearctic *Smithistruma* spp.; pronotum not broad, but relatively long, its lateral plates taking up nearly half the length of the sides; humeri rounded. Pronotum with marginate anterior border; dorsum sloping and gently convex in both directions and feebly submarginate on the sides posteriorly, the highest point of the convexity seen from lateral view reached at the very feebly indicated line of the promesonotal suture, posterior to which the dorsal profile of the mesonotum and propodeum together form a straight, uninterrupted outline to the bases of the propodeal teeth. Mesonotum not distinctly marginate, sides converging behind. Metanotal groove very feeble; propodeal dorsum very short, much broader than long, dropping off quickly through a rounded angle into the declivity; dorsolateral propodeal carinae produced posteriorly as the bases, rectangular in lateral view, of the small, weakly acute, lamelliform propodeal teeth; the latter weakly elevated and continued ventrally as thin, narrow, feebly concave infradental lamellae.

Petiolar peduncle slender, subconical, slightly longer than the anteroposteriorly compressed node; the node more than twice as broad as long seen from above and with a narrowly rounded summit as seen from the side. Posterior collar and posterolateral lobes of spongiform tissue reduced to fine, thin transparent vestiges; median ventral strip well developed. Postpetiole transversely elliptical, 0.24 mm. wide, more than half again as broad as the petiolar node and nearly twice as broad as its own length; dorsal surface strongly convex, nearly as high as the petiolar node; posterolateral and ventral spongiform appendages well developed. Gaster more convex ventrally than dorsally, with a small anteroventral pad and a broad anterior margin of spongy lamellar material, the latter broadly emarginate in the middle. Gastric costulae numerous, fine but distinct, extending 1/3 or a little more the length of gastric tergite I and showing a slight tendency toward bilateralization, but not separated by a median gap.

Gaster (except for costulae), pronotum, entire sides of alitrunk, and pedicellar nodes smooth or very nearly so, strongly shining. Head, except clypeus, densely and rather deeply punctulate, the tendency toward rugulosity less marked than in *thaxteri*. Bottoms of some of the punctulae shining as minute brilliant points, but the surface generally opaque. Clypeus feebly and very superficially longitudinally punctured, but the general effect one of a fairly smooth and rather strongly shining surface. Dorsal surface of mesonotum and sides of petiolar peduncle densely and distinctly punctulate, opaque to subopaque. Propodeum feebly coriaceous, shining. Legs, mandibles and antennae densely, feebly and minutely punctulate-granulose, weakly shining.

Ground pilosity of head consisting of a moderately dense cover of fine, moderately long, tapered hairs, subappressed and recumbent, directed anteriorly, many feebly arched. A similar, but much more scanty cover on the alitrunk, most of the hairs appressed or subappressed and directed mesially. A very few fine appressed hairs, directed posteriorly, on the dorsal surfaces of postpetiole and gaster. Ventral surfaces of head and gaster also



with fine appressed pilosity. Clypeus set with very small, fine appressed subspatulate hairs, directed anteriorly; no hairs forming a prominent projecting fringe along free clypeal border. Mandibles, antennae and legs with fine, short, appressed and subappressed hairs, directed toward the apices of the various members. Long, fine, specialized outstanding hairs, bilaterally paired: one hair on each occipital corner; one on each lateral occipital border, arched anteriorly; one on each humerus, directed laterally; one on each side of mesonotum, directed anterolaterally; pairs on each node, arched posteriad; sparse growth of very fine but truncate erect hairs on gastric dorsum, becoming more abundant toward apex both dorsally and ventrally. Pilosity in general decidedly shorter, less abundant and less conspicuous than that of *thaxteri*.

Color castaneous; head darker, blackish-brown except for clypeus and mandibles, which are ferruginous; gaster a trifle lighter than the alitrunk; legs and antennae sordid ferruginous yellow.

Holotype worker a unique [MCZ] found dead in a small snail shell collected at 5000 feet on the east side of the Nyika Plateau, above Nchenachena, Northern Nyasaland, by Mr. Arthur Loveridge of the Museum of Comparative Zoology. The shell, when first examined by Dr. J. C. Bequaert in the Museum, was seen to contain dried earth and the damaged body of a small black tetramorine ant, probably *Xiphomyrmex*. Upon carelessly crushing the shell with my finger, I noticed the present specimen in the deeper recesses of the shell. Minute examination of the shell fragments revealed no further insect remains.

Mr. Loveridge informs me that the Nyika Plateau, which is on the western side of Lake Nyasa, has a cool, wet climate of a type inhospitable to human enterprise. The Plateau was formerly heavily timbered, but such forest as now remains in the area of this collection is mostly restricted to the ravines. This is the first species of the *Codiomyrmex-Glamiomyrmex* group of genera to be found outside the New World tropics. It is apparently a remnant of a once widespread fauna now reduced to a few rare species inhabiting limited refugia. Because of the great discontinuity in the distribution, I was at first reluctant to assign this species to *Codiomyrmex*. After long and thorough comparison with the types of *C. thaxteri*, however, I am forced to the conclusion that the two species are so closely allied that little would be gained by separating them into different genera. Since Thaxter took the types of *thaxteri* in sweepings at Port of Spain, we must consider the possibility that the latter species, like other ants occurring in the same vicinity, may be an accidental importation via human commerce, perhaps originating on African shores.

*Codiomyrmex loveridgei* can be separated from other short-mandibulate African genera by means of its broad and very convex mandibles with their reduced number of serial teeth (8). The sculpture, pilosity, and very dark color are also distinctive.

### **Borgmeierita new genus**

*Codiomyrmex sensu* Weber, 1934, Revista de Ent. 4:51-52, part. Brown, 1948, Trans. Amer. Ent. Soc. 74:114-115, part. (Not Wheeler, 1916).

**Worker:** Size small. Related to *Codiomyrmex* and *Glamiomyrmex*, but differing in lacking the small ventral premandibular teeth; in having strong, spaced, predominantly longitudinal costulate sculpture; and in the shape of the postpetiole, which is broad and exaggerated-reniform or C-shaped, its blunt anterolateral arms embracing the posterior part of the petiole. Pilosity fine, sparse. Color rather dark.

**Genotype:** *Codiomyrmex excisus* Weber (by present designation, monobasic).

#### **BORGMEIERITA EXCISA (Weber)**

*Codiomyrmex excisus* Weber, 1934, Revista de Ent. 4:51-52, fig. 9, worker. *Codiomyrmex excisus* Brown, 1948, Trans. Amer. Ent. Soc. 74:115.

**Holotype Worker:** (Remounted dry on conventional points and remeasured) TL 2.30, HL 0.55, WL 0.57, CI 84, MI 18. For the original description, the unique type was placed by its original author in a balsam mount between two cover slips, where it rested in a laterally tilted position. Since I could not find agreement in some views



between Weber's characterization and figure and the specimen itself, the mount was dissolved and the major parts mounted on three separate points; the parts were separated in the balsam. An antennal funiculus, legs and smaller mouthparts were remounted in damar on a conventional slide, and the slide and pin given the same type catalog number [MCZ no. 22444] and placed in the same tray.

The head as now seen differs considerably from Weber's figure, especially since the posterior median portion of the occiput was transparent and entirely invisible in the balsam when viewed from the position as indicated by the figure. What Weber shows as the deep, rounded portion of the occipital excision is actually the heavy ventral border of the occipital foramen; in the balsam, this border of the foramen was very distinctly visible through the highly transparent cephalic dorsum. If one draws a straight line transversely across the occipital excision as shown in Weber's figure at about the middle of its depth, the resulting occipital outline is approximately as in the specimen presently seen from a directly dorsal position. The excision, therefore, is only about half as deep as shown in the figure, and has a nearly straight, transverse bottom; the occipital lobes, while still projecting posteriorly and with narrowly rounded apices, are much less prominent seen in this mount. The clypeus is broadly subpentagonal, about  $1\frac{1}{4}$  times as broad as long; anterior border very broadly and weakly concave; surface of clypeal disc feebly convex in the middle. Mandibles robust and arched, strongly convex dorsally, much as in *Glamyromymex* and *Codiomyrmex* species, with a large, partly exposed basal lamella, no diastema, 7 stout acute teeth in the principal apical series, increasing gradually in length to nos. 5 and 6; 7 shorter, followed by a very short preapical series of a few denticles and a small apical tooth. Masticatory borders of opposite mandibles meet along the midline; the oblique line of closure in Weber's figure is due to tilting and distortion of the specimen in the balsam. Underside of head a short distance behind the oral region with a very deep, narrow transverse fossa. Antennal scrobes deep and broad, overhung by the dorsal borders; eyes small, placed on the dorsal side of the ventral scrobe borders at about the midlength of the head. Antennae short and thick, much as in *Codiomyrmex*, etc.

Alitrunk as described by Weber, with low, obtuse humeral angles; propodeal teeth broken, but described by Weber, evidently before immersion in the balsam, as rather long and acute. Anterior propodeal margin marked by a transverse carinula. Petiole with a distinct node, the summit somewhat flattened and very slightly longer than broad, without spongiform appendages. Postpetiole very distinctive, narrow transverse-subreniform or C-shaped, with the concavity anterior, receiving the posterior part of the petiolar node. Spongiform appendages limited to thin plates on the posterolateral margins, opposing similar masses on the anterolateral gastric borders. Ventral appendages vestigial.

Body in general smooth or nearly so, shining, with rather coarse, well separated longitudinal costulae on the head posterior to clypeus and on the dorsum of the thorax (none on propodeum). On the occiput, the slightly irregular longitudinal costulae are sparsely connected by a few transverse spurs or branch costulae. Petiolar node irregularly rugulose, subopaque.

The pilosity is now completely gone, but Weber says of its former state: "Hairs of body long and fine, sparsely distributed; no squamiform or clavate hairs. Pubescence fine and appressed."

Color deep reddish brown; appendages lighter and more yellowish.

Type locality: Tuli Creek, near San Miguel, Nicaragua (C. R. Halter). Taken from the stomach of a toad, *Dendrobates tinctorius*, found on the forest floor.

#### WEBERISTRUMA BROWN

*Smithistruma* (*Weberistruma*) Brown, 1948, Trans. Amer. Ent. Soc. 74:106-107. *Strumigenys* of authors, part. (not Fred. Smith). *Strumigenys* (*Cephaloxys*) of authors, part. (not Fred. Smith). *Smithistruma* (*Smithistruma*) Brown, 1948, Trans. Amer. Ent. Soc. 74:105, part. *Weberistruma* Brown, 1949, Mushi 20:7-9, see also pp. 6, 22, 25.

Genotype: *Strumigenys* (*Cephaloxys*) *leptothrix* Wheeler (monobasic).

Worker: Related to *Smithistruma*, but averaging larger, with more elongate body and relatively longer, more slender legs. Head in dorsal view elongate, cuneiform, resembling in habitus the species of the *clypeata* group of

*Smithistruma*, but with decidedly broader, more convex mandibles. The convex dorsal mandibular surfaces appear slightly bulging at the base, especially in comparison to the rounded free clypeal border; the latter rather low. Eyes placed ventrally in the antennal scrobes and distinctly behind the midlength of the head. Occipital lobes feebly or not expanded posteriorly and only weakly so laterally; posterior occipital excision feeble to moderate. Antennal scapes relatively longer and more slender than in *Smithistruma*; funiculus only moderately incrassate, the apical segment slightly shorter, or at least not longer, than the four basal segments taken together. Petiolar node, at least in the species seen for this work, low, elongate, and only very weakly differentiated from its peduncle. Propodeal teeth well developed and acute, infradental lamellae variable, but the ventral angles in some cases produced as acute teeth.

The characters of sculpture cited by me as of generic significance in former descriptions must be abandoned due to differences encountered in forms newly placed in the genus. The sculpture varies widely, showing much the same range of variation among species as in *Smithistruma*.

Pilosity also more variable than formerly supposed; ground pilosity of anterior cephalic dorsum consisting usually of small and rather inconspicuous appressed or subappressed hairs; clypeal hairs small and appressed, usually more densely crowded along the free border, especially in the anteromedian region, but not forming a conspicuous fringe as in the majority of *Smithistruma* species. Posterior cephalic dorsum and alitrunk with rather numerous slender erect hairs, truncate or weakly clavate at their apices. A sparse growth of erect hairs also on nodes and gaster.

Color varying widely with the species, running through all shades of ferrugineosity.

*Female:* Known for only one species. Differs from the worker in the usual ways. Male unknown.

At the time of my original description of *Weberistruma*, I was acquainted with only the genotype as a possible candidate for inclusion. By 1949, I had seen *jacobsoni*, and this species was added. Since that publication, I have been able to examine specimens of *rudinodis* Starcke and have had Yano's figure of *Strumigenys japonica*, which figure I had previously overlooked, called to my attention by Dr. Kikumaru Okano. I am positive that *rudinodis* is a *Weberistruma*, although an aberrant one, and I am reasonably certain that the ant figured by Yano must also be placed in this genus. The diversity of these species, while making necessary certain changes in the generic definition, strengthens rather than weakens the conception of *Weberistruma* as a separate genus, for it is now possible to detect the basic underlying differences from the related *Smithistruma* and to discard the more superficial characters as variable with the species.

It may be noted that *Weberistruma* does not differ startlingly from *Smithistruma* by very many details, but these details are all-important as generic characters and seem, from the present knowledge of the two groups, to apply with considerable constancy. Beyond these characters, however, there is a certain subtle but none the less sensible difference in the "balance" or habitus of the species of the two genera that can be appreciated only in the examination of actual specimens.

From our present knowledge, the range of *Weberistruma* lies entirely within the Indomalayan region, with a northward extension to Hondo. Although no species are yet known from the mainland of Asia, it appears probable that the genus will eventually be found in warm temperate China and in the more tropical parts of Southeast Asia. Other species almost certainly occur in the Philippines and Borneo; it is only a matter of a wait for their discovery. The distribution appears to be more or less discontinuous, no two species having yet been taken on the same island.

Phylogenetically, *Weberistruma* appears to be intermediate between *Smithistruma* and *Codiomyrmex*. The mandibles outwardly are very similar to those of *Codiomyrmex thaxteri*, and though no dissection has been made for any species, there is no reason to believe that the dentition is very different from that of either related genus. Nothing is known of the feeding habits, but the known nesting sites, especially of *jacobsoni* in a fungus, suggest that the prey may be the same as for *Smithistruma*.

The species *leptothrix* (Wheeler) from Formosa and *jacobsoni* (Menozzi) from Sumatra have been discussed in detail in Part I of this revision (1949). The two other species are treated briefly below.

#### WEBERISTRUMA RUDINODIS (Stärcke)

*Strumigenys* (*Cephaloxys*) *inezae* var. *rudinodis* Stärcke, 1941, Tijdschr. v. Ent. 74, Verslag, pp. ii-vi, worker, morphology, biology, etc.

*Worker*. TL 3.04-3.12, HL 0.72-0.74, WL 0.81-0.84, CI 68-70, MI 17-18). (Measurements and description based on four paratypes sent by Dr. Stärcke.)

This species is large, slender and quite long-legged for a *smithistrumiform* ant. Head form much as in other *Weberistruma* species. Antennal scape as normally exposed about 0.41 mm. long in an "average" specimen, slightly thickened in apical half, faintly sigmoidal. Funiculus in same specimen about 0.63 mm. long; apical segment slightly shorter than I-IV taken together; IV slightly longer than I; I subequal in length to II + III; II and III both slightly longer than broad (cf. original description).

Promesonotum markedly depressed, only weakly convex, but not greatly broadened and with only the finest of dorsolateral carinulae forming distinct but feeble margins on each side posteriorly at the level of the mesonotum. Pronotum narrowly rounded anteriorly, without humeral angles; no margin separating pronotal dorsum from dorsum of "neck." Posterior mesonotum forming a laterally marginate concavity ending at the very feeble metanotal groove, the later distinct at all only because the propodeal dorsum rises very slightly but rather abruptly from it posteriorly. Propodeal dorsum flat, its sides submarginate, diverging posteriorly and continued as the long, sharp, somewhat depressed propodeal teeth. These teeth are as long as or slightly longer than the distance between the centers of their bases and are slightly elevated and diverging posteriorly. Infradental lamellae reduced to low, even carinae, each of which has developed at its ventral extremity a prominent, acute tooth, inclined dorsad and about half as long as the dorsal tooth. Lateral aperture of transsternal groove (above and behind anterior coxa) rather conspicuous, the fine hairs evident; suture running dorsad from it rather fine.

Petiolear node extremely poorly defined, its dorsal surface continuous with and a little longer than its peduncular dorsum. Node seen from above subovate, narrowed anteriorly, not more than  $\frac{3}{4}$  as broad behind as long (cf. original description). Posterior spongiform collar only weakly developed, narrow; midventral strip well developed, areolate, the anterior part forming a deep rounded hanging lobe. Postpetiole depressed-subglobose, but distinctly broader than long; shorter, and about  $\frac{1}{3}$  broader than the petiolear node; a feeble longitudinal costula traversing the length of the dorsal face on each side, other costulae feebly suggested. Spongiform appendages only moderately well developed except ventrally, where much-areolated hanging lobes are fairly heavy. Gaster long-oval, pointed at apex, feebly depressed dorsally, very slightly wider than the head; transverse anterodorsal border and anteroventral pad of spongiform tissue moderately

developed; basal costulae subvestigial, very short and few, not more than 10 in my specimens; gastric surface smooth and shining.

Entire head, including clypeus, entire alitrunk, legs and both nodes densely punctulate-granulose and opaque.

Ground pilosity on the anterior  $\frac{3}{4}$  of cephalic dorsum composed of short, fine, inconspicuous appressed hairs, directed anteromedially for the most part. Clypeus and mandibles with similar hairs, narrowly spatulate, more densely arranged and a little more conspicuous, but not longer; closely appressed; those in the center of the clypeus anteriorly most densely packed, oblique, and forming a sort of blunt anteromedian peak to the anterior free clypeal border; however, this illusion disappears under benzine, when the actual clypeal border at this limited median point appears truncate or feebly subemarginate. Hairs on scapes short, fine, subappressed, directed apicad. Hairs of underside of head, tibiae and tarsi also fine, reclinate, directed distally.

Erect pilosity consisting of long whitish hairs, stiff but weak, not apically enlarged, but more or less distinctly truncate apically, averaging 0.12-0.15 mm. in length, a bit shorter on the head than on alitrunk, distributed as follows: 25-30 on the posterior third of the cephalic dorsum, weakly curved anteriorly; 20 or so on the dorsum of the alitrunk, mostly restricted to origins near or on the lateral margins; a few on each of the nodes; a sparse growth of perhaps 30 on the gastric dorsum, tending toward arrangement in transverse rows of four. Venter of gaster and surfaces of femora with similar, but slightly shorter hairs, both perpendicularly and obliquely erect.

Color in my specimens bright ferruginous yellow, but these are evidently teneral, for Stårcke notes in his description that some of his workers are more deeply colored: "De volkomen uitgekleurde werkers zijn roestbruin, met de middelste  $\frac{5}{6}$  van het gaster donkerbruin, doch de meeste individuen zijn niet uitgekleurd, van stroogeel tot bruingeel."

Holotype in Stårcke Collection; paratype in Mus. Amsterdam, Mus. Leiden, ZMLB, MCZ, USNM, Weber Coll.

Dr. Stårcke's article contains morphological, biological and other information on this species. His very brief actual description contains some very small measurements, and is mainly comparative against *inezae*. However, he writes me that he has seen no specimens referable to *inezae* or to any of the variants placed infraspecific to it by other authors. While I have not seen specimens of *inezae* myself, circumstantial evidence I have presented elsewhere indicates strongly that *inezae* is a *Smithistruma* of the *capitata* group and an ant very different from the present species of *Weberistruma*. The type locality is Poentjak Pass, near Buitenzorg, Java 1400 M. (E. Jacobson).

#### WEBERISTRUMA JAPONICA (Ito)

*Strumigenys japonica* Ito, 1914, Ann. Soc. Ent. Belg. 58:40-41, worker. *Strumigenys* (*Cephaloxys*) *japonica* Emery, 1922, Gen. Ins. Fasc. 174:325 (not Wheeler, 1928). *Strumigenys japonicus* Yano, 1932, in Icon. Insect. Japon., Tokyo, p. 335, fig. 653, worker. *Smithistruma* (*Smithistruma*) *japonica* Brown, 1948, Trans. Amer. Ent. Soc. 74:105, part. 1949, Mushi 20:10, 22.

The original description of this species is virtually worthless. The female assigned to the species by Wheeler in 1928 was separated by me as a new species of *Smithistruma* in 1949 (loc. cit.); in the same paper, I assigned *japonica sensu* Ito to *Smithistruma* provisionally and with doubt. Since that time, Dr. Okano has called to my attention Yano's figure, which I had overlooked in 1949. While this figure and the accompanying description (kindly translated for me by Mr. F. Y. Cheng) add little of specific descriptive value, the figure is sufficiently good that the ant serving as its model is recognizable as a *Weberistruma*.

The question arises at once, however, as to whether the insect figured by Yano is the same as that described by Ito. Yano definitely had not seen Ito's types, the present location of these being unknown, according to an investigation kindly carried out by Dr. Keizô Yasumatsu (in litt.). Nevertheless, I believe that Yano's identification is correct, if only in the correspondence in the two series of large size ("2.5 mm.") and similar locality (Type locality: "Prov. Nagato . . . Hondo; Y. Nawa, collector.") I believe that the measurements will exceed 2.5 millimeters when carefully made, but even if the previously published values are correct, the size is larger than any other known smithistrumiform species from Japan. Certainly no purpose is served, under the circumstances, in

proposing a new name for Yano's specimens. Mr. Cheng's translation of Yano's description is given here with liberal adaptation:

"Body reddish-brown; dorsum of head and basal gastric segment darkened. Clypeus [?], mandibles and legs sordid yellowish-brown. Anterior part of head and scapes with dense yellowish-white squamose [!] pilosity. Prothorax with short [erect?] yellowish hairs, becoming very long on petiole, postpetiole and gaster. Petiole long, its peduncle slender; postpetiole short; both with ventral spongiform appendages. Head long and slender, anteriorly produced; posterior part wider; occipital border concave in the middle. Compound eyes small, situated behind midlength of head. Funiculus with 5 segments, apical longest and broadest. Mandibles broad, inner borders multidentate. Body length about 2.5 mm. Native to Hondo, under stones."

Dr. Okano writes that he has some of Yano's specimens, which he plans to redescribe at an early date.

#### STRUMIGENYS Fred. Smith

This genus, the largest in the Dacetini, will be treated fully at a later date. I shall discuss here only the species *S. louisianae*, which enters the southern Nearctic Region as the sole representative of the genus there.

#### STRUMIGENYS (STRUMIGENYS) LOUISIANAE Roger

Text-figs. 1, 3

*Strumigenys louisianae* Roger, 1863, Berl. Ent. Zeitschr. 7:211, worker. *Strumigenys louisianae* Emery, 1895, Zool. Jahrb. Syst. 8:327 (syn. *unispinulosa*). Wheeler, 1908, Bull. Amer. Mus. Nat. Hist. 24:145, 147. Menozzi, 1927, Ent. Mitt. 16:268. *Strumigenys unispinulosa* Emery, 1890, Bull. Soc. Ent. Ital. 22:67, Pl. 7, fig. 5, worker. 1892 (?) An. Mus. Nac. Costa Rica, 1888-1889, p. 58, Pl. 1, fig. 12, worker. Wheeler and Mann, 1914, Bull. Amer. Mus. Nat. Hist. 33:40. *Strumigenys unispinulosa* var. *longicornis*, Emery, 1894, Bull. Soc. Ent. Ital. 26:214, worker. 1922, Gen. Ins. Fasc. 174:322, as *S. (s. str.) louisianae* var. (new syn., with doubt). *Strumigenys louisianae* var. *obscuriventris* Wheeler, 1908, Bull. Amer. Mus. Nat. Hist. 24:145, Pl. 12, fig. 14, worker. Santschi, 1931, Revista de Ent. 1:275, Cuban rec. Weber, 1934, Revista de Ent. 4:39, as subsp. M. R. Smith, 1936, Jour. Agr. Univ. P. Rico 20:857, fig. 13, worker. (new syn.) *Strumigenys bruchi* Forel, 1912, Mem. Soc. Ent. Belg. 29:197-198, worker, male (new syn.) *Strumigenys infidelis* Santschi, 1919, An. Soc. Cient. Argent. 87:48, worker. (new syn.) *Strumigenys eggersi* var. *cubaensis* Mann, 1920, Bull. Amer. Mus. Nat. Hist. 42:430, worker. (new syn.) *Strumigenys (s. str.) louisianae* subsp. *laticephala* M. R. Smith, 1931, Ann. Ent. Soc. Amer. 24:690-691, Pl. 1, fig. 2, worker. Haug, 1932, Ann. Ent. Soc. Amer. 25:170-172, figs. 1, 2, male. Creighton, 1937, Psyche 44:97-109, fig. 1, biology. M. R. Smith, 1947, Amer. Midl. Nat. 37:585, Pl. 14, fig. 53. (new syn.) *Strumigenys (s. str.) louisianae* subsp. *soledadensis* Weber, 1934, Revista de Ent. 4:38-39, worker, female. (new syn.) *Strumigenys (s. str.) louisianae* subsp. *guatemalensis* Weber, 1934, Revista de Ent. 4:39, worker. (new syn.) *Strumigenys (s. str.) louisianae* subsp. *costaricensis* Weber, 1934, Revista de Ent. 4:39, worker. (new syn.) *Strumigenys (s. str.) louisianae* Emery, 1922, Gen. Ins. Fasc. 174:322. M. R. Smith, 1931, Ann. Ent. Soc. Amer. 24:689-690, Pl. 1, fig. 1, worker. Weber, 1934, Revista de Ent. 4:36, 38, worker. (In the above synonymy are included only those citations that add to the knowledge of the species, or make some taxonomic change, or are interesting and pertinent for other reasons. Several references giving mere records within the known range are not listed.)

The new synonymy recorded above will seem incredible to a myrmecologist used to handling the various names included. Nevertheless, I have seen types of all forms mentioned except *louisianae* itself, var. *longicornis*, and the species Emery himself synonymized early, *S. unispinulosa*. These appear to me to be undoubted specimens of *louisianae*; I have little doubt about the "typical" form, since I am quite sure that it is the only form presently recorded from within the United States. The forms described by Wheeler, Santschi and Forel may be put down to the carelessness of these authors in failing to check their types against the species that already had fallen into synonymy. The types of these forms do not differ in any way from specimens that can be selected from North Carolina series.

Mann's *cubaensis* was accidentally put into the wrong species, and has therefore gone

undetected; it antedates Weber's *soledadensis* and has the same type locality. The types do not differ from specimens from any localities in the United States. The form *laticephala* is in actuality the commonly-encountered "normal" form of *louisianae*; what Smith thought to be the "typical" form is less common, but can be found over the same range as *laticephala*. The narrow- and broad-headed forms are frequently found in the same nest, though usually one nest will show relative restriction of the range of variation of the cephalic index. Nests ranging from one end of the scale of cephalic indices to the other without discontinuity may be found anywhere within the range of the species in the United States. The theory of Creighton that the "typical" *louisianae* is more southern in range than *laticephala* will not hold from the series presently available to me.

In 1934, Weber made a serious attempt to put the variants of this species on a basis of geographical variation. First he measured seven specimens from Texas and Florida, determining with a fair degree of accuracy the length of the head including mandibles, length of funiculi, and proportion of length of mandibles to length of head proper. He then made similar measurements on small series of workers ("6 to 8 specimens") from various other localities. On the basis of his findings, and ignoring species described from some of the same areas previously, he set up his new subspecies and "confirmed" Wheeler's *obscuriventris*. All this was done on the basis of very small "average" differences between the values for the various series; neither range of measurements nor error of measurement were cited. I have repeated the measurements of Weber, not only upon the same specimens he used as types, but also upon 110 workers from various North American collections (Tennessee, North Carolina, Alabama, Georgia, Florida, Mississippi, Louisiana, Texas), plus about 60 specimens representing the Neotropical localities from which material is listed below. The North American specimens will cover in degree of variation, matching exactly in any quantitative character, any of Weber's specimens that may be chosen, providing the normal error of measurement is taken into account. Some of the South American specimens are a bit outside this range of variation, especially some of those from Argentine and Bolivia; this is to be expected, for some part of South America, not North America, is surely the center of distribution. Specimens of this ant from northern Argentina, however, will match perfectly many from the North American series.

In sum, *louisianae* is a variable ant, ranging from northeastern Tennessee to northern Argentina and Bolivia. It is not so variable, however, as might account for the relatively large number of synonyms, a number that can be put down only to carelessness on the part of several authors who do not seem to have bothered to check the literature or their own collections very far. The variation is greatest in South and Central America, and is apparently restricted by the relatively rigorous selectivity of the climate in North America. Though the type locality is Louisiana, I cannot see that this affects the synonymy in any way. If specimens from nests in Argentina cannot be differentiated from those in Louisiana, as in my finding, then we are dealing with one widespread species.

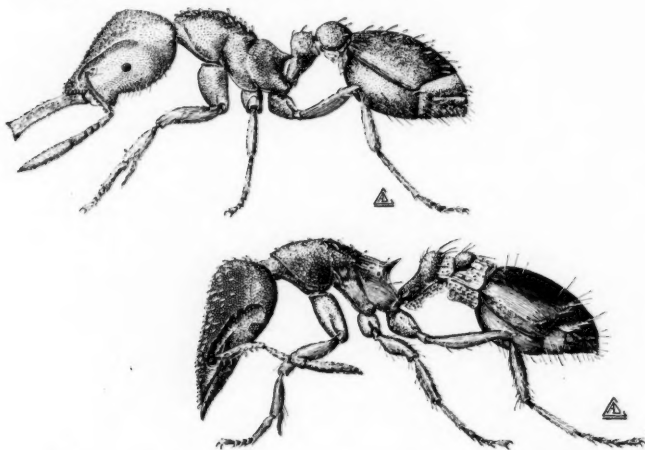
Results of statistical treatment of the various population samples showed lack of significant apportionment of any character that could be put into quantitative terms, except possibly in the case of the Bolivian sample, which showed very short heads, but in which the mandibles were not significantly shorter in absolute terms than were those of other regions. These specimens have, therefore, a relatively high mandibular index and relatively long antennal scapes compared to the head proper, and this fits Emery's characterization of *longicornis*. I am considering the variety *longicornis* as a synonym, however, because I feel that the difference is too slight to be really significant and because the material is representative of only one colony-series. Since no collection of *louisianae* have yet been made in the Amazon Basin or other parts of Brazil, where the species must be present and very variable in at least some areas, I believe that the present estimate of the variability may be low.

The range of some measurements on the combined worker specimens from the North American and other localities is as follows: HL 0.47-0.65, ML 0.26-0.40, CI 79-89, MI 50-63. Undoubtedly, specimens will be found to exceed these ranges slightly in one direction or another, but I doubt if many such specimens will come from North America. So far as is known, the smallest specimens come from Mexico and Argentina, and the largest ones from Argentina. Argentinian specimens intergrade from the largest to the smallest in a perfectly continuous series.

The species has been figured well and described so many times that redescription here would be completely superfluous. For a characterization of the worker, the references of

Smith (1931, 1947) are suggested, while the male has been treated very well by Haug (1932). Weber has described the female adequately under the name *soledadensis* (loc. cit.).

It is felt that the great difficulty experienced by some workers in determining specimens belonging to the *louisianae* group is due largely to the great uncertainty brought about by the excessive unrecognized synonymy. Once the variability and different treatments of the various authors are thoroughly understood, identification should be an easy matter. Practically every worker who would normally be interested in this form will find that he has specimens in his collection, for this is a very commonly collected ant in the warmer parts of the New World. There are, however, a number of undescribed species closely related to *louisianae*, but distinct by what I consider to be significant characters. These will be described at an early date, in the general treatment of the Tropical American *Strumigenys* I have nearly completed in manuscript.



Text figs. 1, 2.—1. (above) *Strumigenys louisianae* Roger, worker, lateral view (after M. R. Smith); 2. (below) *Smithistruma rostrata* (Emery), worker, lateral view. Specialized erect hairs of occiput, humeri, and mesonotum not shown (after M. R. Smith).

The worker type of *louisianae* is apparently in the Roger Collection, ZMUB. Types of *unispinulosa* and *longicornis*, Emery Coll.; *infidelis*, Santschi Coll., MCZ, Borgmeier Coll.; *cubaensis*, Mann Coll., MCZ; *obscuriventris*, AMNH, MCZ; *bruchi*, Forel Coll., MCZ; *laticephala*, USNM, MCZ, etc.; *soledadensis*, *costaricensis*, *guatemalensis*, MCZ.

Type locality: "Louisiana" (J. Roger).

#### MATERIAL EXAMINED

UNITED STATES: Abundant material representing over 50 colonies from various localities in North Carolina (D. L. Wray); Tennessee (L. G. Wesson, D. W. Pfitzer, J. W. Jones); Georgia (H. Hoogstraal, J. C. Bradley); Florida (A. Van Pelt, P. J. Schmitt); Alabama (E. O. Wilson, B. D. Valentine, W. S. Creighton); Mississippi (M. R. Smith and others); Louisiana (F. G. Werner, H. S. Dybas, C. L. Remington, W. L. Brown); Texas (W. M. Wheeler, C. F. Baker); Arizona, Hot Springs (Schwarz and Barber: Mr. Barber assures me that this specimen, which I have not seen, but which has been determined by Dr. M. R. Smith and is therefore considered perfectly reliable, was taken under conditions that would lead one to believe that the record does not represent a chance introduction into Arizona. If so, this is a rather remarkable locality, for *louisianae* has not been taken in nature at any other point west of central Texas and north



of the Mexican Border, in spite of heavy collecting by myrmecologists and other entomologists in this region.) Many other series seen by the author but not measured are omitted from mention.

MEXICO: Nautla, Vera Cruz; Necaxa, Puebla (F. Bonet). Mexico, D. F.; Banderilla, Vera Cruz (U. S. Plant Quarantine).

GUATEMALA: Zacapa (W. M. Wheeler). Escuintla (W. M. Mann).

COSTA RICA: Colombiana Farm, Santa Clara Prov. (W. M. Mann). San José (H. Schmidt). Cartago (W. M. Wheeler). Hamburg Farm, S. Clara Prov. (F. Nevermann).

CUBA: Soledad, Cienfuegos (W. M. Mann; N. A. Weber). Almenvales (A. Bierig).

HAITI: Diquini; Cape Haitien (W. M. Mann).

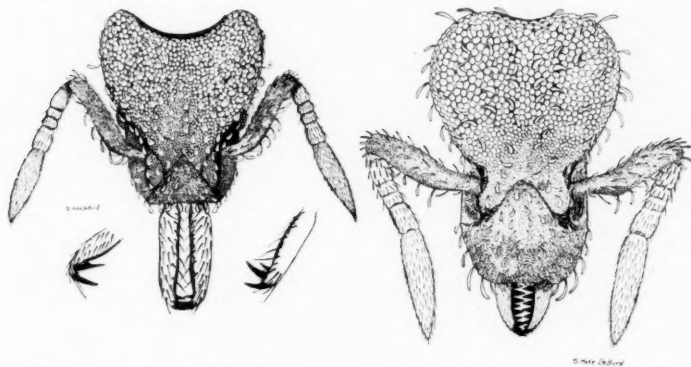
PUERTO RICO: Utuado; Coamo Springs (W. M. Wheeler). Mayagüez (M. R. Smith).

COLOMBIA: Río Porce, 1020 M., no. 989; Medellín, 1800 M., no. 919 (N. A. Weber). "Colombia" (U. S. Plant Quarantine).

BOLIVIA: Rosario, Lake Rocagua (W. M. Mann).

ARGENTINA: "La Plata" (C. Bruch; the types of both *bruchi* and *infidelis* bear this same vague locality). Reducción, Laguna de Calimayo (N. Kusnezov); Los Puestos (Kusnezov and Golbach).

The total absence of this species in collections of dacetines from Barro Colorado Island, British Guiana and Brazil is rather surprising. Perhaps it is really absent or very rare in the true rain-forest belts.



Text figs. 3, 4.—3. (left) *Strumigenys louisianae* Roger, worker, head in full-face view (after M. R. Smith); 4. (right) *Smithistruma* (s. str.) *rostrata* (Emery), worker, head in full-face view (after M. R. Smith).

#### SMITHISTRUMA Brown

*Smithistruma* Brown, 1948, Trans. Amer. Ent. Soc. 74:104 et suiv., part. *Strumigenys* of authors, part., not Fred. Smith 1860. *Cephaloxys* Fred. Smith, 1864, Jour. Proc. Linn. Soc. Lond. Zool. 8:77, nom. praeocc. *Strumigenys* (*Trichoscapa*) of authors, part. not Emery 1869. *Epiirritus* Emery, 1875, Ann. Mus. Civ. Stor. Nat. Genova 7:474, part. *Strumigenys* (*Cephaloxys*) of authors, part.

Genotype: *Strumigenys pulchella* Emery (by designation of Brown, 1948).

#### HISTORICAL

*Smithistruma* was raised in 1948 to include the majority of "short-mandibulate" species included up to that time in *Strumigenys*. It was demonstrated

there that the species with short mandibles actually represented several distinct stocks that had remained unnoticed in the welter of poorly described and synonymous forms contained in the portmanteau genus *Strumigenys* as treated in Emery's contribution to the *Genera Insectorum* (1922). Emery and others had vaguely recognized only that the old, heterogeneous *Strumigenys* could be divided into two groups, the nominate subgenus and *Cephaloxys*, based on length and other characteristics of the mandibles. In 1943, M. R. Smith showed that *Cephaloxys* was preoccupied and applied Emery's old name *Trichoscapa*, which had earlier been used in the same sense by Santschi, to the assemblage of short-mandibulate forms.

With regard to the latter group, the heart of my revisionary action in 1948 lay in the recognition that the genotype of *Trichoscapa*, *Strumigenys* (*T.*) *membranifera* Emery, is not congeneric with the majority of short-mandibulate forms. When *membranifera* and its synonyms were separated from the mass of short-mandibulate forms, the latter were left without an available generic name. This situation was met by the proposal of a new name (*Smithistruma*) applicable to the aforesaid majority. At the same time, the heterogeneity of *Smithistruma* was recognized by its division into four subgenera. Subgeneric standing was resorted to for the division because I did not on that occasion have the knowledge of all the described species required for clean and certain delimitation of genera, but I felt that certain stocks seemed differentiated well enough to warrant nomenclatorial distinction of some kind. After further research into the characters of the more poorly known species of the *Strumigenys* complex, I was able in 1949 to show that two of the subgenera recognized earlier, *Weberistruma* and *Serrastruma*, were in fact separate genera.

At the present writing, few changes are recognized as necessary in the existing generic structure of *Smithistruma*. By now, all but three or four species of the *Strumigenys* complex are known well enough for certain placement to genus, and this handful of *species inquirendae* contains no form likely to upset the basic arrangement in the smithistrumiform subcomplex. Of the 56 species here recognized as belonging to *Smithistruma*, 53 fall into the nominate subgenus, two go into *Wessonestruma*, and one is herein made the type of a new subgenus, *Platistruma*. Further subdivision along the lines of the species-groups I have used in this work may well be possible in the future, but at present there seems to be no point worth gaining in delimiting these groups as subgenera. The groups are connected or seemingly connected in all directions by intergradient forms, so that most of the limits here drawn are to be considered artificial conveniences of a temporary sort. Furthermore, the addition of new species to the genus at an increasing rate as the rich tropical areas are explored will inevitably make even the "natural" groupings here suggested obsolete within a decade or two.

The present work may be regarded as the first real revision of the genus in a strict sense. While the species retained the generic and subgeneric names *Strumigenys* (*Cephaloxys*) or *Strumigenys* (*Trichoscapa*), a few works did appear in answer to the need for compilations of regional faunas and for keys. While several of these regional works are carefully done and comprehensive within their stated limits, and thus are valuable in any case, none has included purposefully the changes needed to clarify the status of the genera and species

included in the respective areas. These works have for the most part been constructed as the vehicles for new species and for the statement of important biological information, and little attention has been paid to synonymy, supra-specific grouping, or to the important but tedious task of describing the males and females known and associated with the respective workers.

The majority of the regional reviews have little bearing on the present revision for the reasons stated above, except as they contain new species or new morphological, biological or ecological information. The best and most important of these papers have been written by Emery (1895) and certain North American specialists on the Nearctic fauna; among these most constantly referred to here are M. R. Smith (1931), L. and R. Wesson (1939), and, for morphology, Kennedy and Schramm (1933). Although not all strictly in the nature of regional reviews, the various papers of Emery, 1875, 1890, 1894, 1895, 1905, 1916, 1922) are noteworthy both in that their author brought forth many useful (but since neglected) characters and in the fact that he continually strove by means of figures and annotations to fill the gaps left by the hasty, incomplete work of Forel and Santschi in the knowledge of the species described by the two latter authors from the Mediterranean area and the Americas. Undoubtedly Emery knew more about the higher dacetines than did either of his contemporaries, and had he not been overtaxed in his lonely job of clearing up the messes left by the others in general formicid taxonomy, he might have found the time to seek logical generic arrangement for the dacetines many years ago.

Other than the literature mentioned, the writings on the species now placed in *Smithistruma* are scattered as bits and pieces, mostly in the form of stark specific descriptions with a sprinkling of worthless keys, throughout the myrmecological literature from the 1860's to the present.

The knowledge of the biology of the species really begins with 1936, in which year L. G. Wesson made the definitive observations of *S. pergandei* feeding upon Collembola. Due to further observations by the Wesson brothers (1939) and others (especially E. O. Wilson, in press), this remarkable prey specificity is known to be more or less faithfully followed by several species in different genera of the *Strumigenys* complex, and is therefore thought to be basic to their ethology. Previous to 1936, the opinion had prevailed that the higher dacetines were fungus-feeders (cf. Forel 1893, Kennedy and Schramm 1933), largely due to the mistaken notion that the Dacetini were closely related to the Attini. Aside from feeding habits, however, the literature contains quite a few references, mostly very brief, citing nesting habits and other data concerning ethology and ecology of *Smithistruma* species. The two papers by L. G. Wesson cited above are in this respect also easily the best in the field. It remains for the present paper to extend and generalize upon the observations of the Wessons and to collect and evaluate the great number of individual observations and collecting records, both in the literature and out.

#### EXTERNAL MORPHOLOGY

*Worker:* The *Smithistruma* worker is essentially a *Strumigenys* with short, subtriangular mandibles lacking a true apical fork of spiniform teeth. The head is usually a little longer and more depressed than in *Strumigenys*,

with the occipital lobes in general less prominent and expanded, as might be expected from the lesser bulk of the mandibles. The shape of the head may be described as depressed-pyiform, -sagittiform, or -cuneiform, always more or less broadly and deeply excised at the posterior occipital border. As in *Strumigenys*, broad lateral antennal scrobes are present, these occupying the larger part of the sides of the head and usually terminating at or just anterior to the point on each occipital lobe that reaches farthest to the sides. The clypeus is broad and shield-like, usually more strongly developed than in *Strumigenys*, its free border extended as a covering over a considerable portion of the mandibular bases when the mandibles are fully closed. The free clypeal border may have one or two margins and may be broadly rounded, truncate, bluntly pointed, or emarginate to varying degrees. The plane or weakly concave or weakly convex dorsal surface of the clypeus is here called *clypeal disc*. The disc shows a small raised *tumulus* with varying distinctness at or slightly posterior to the center of the free clypeal border; the tumulus is often more or less shining, with thin, transparent integument, and it seems to have some sort of connection to the labral apparatus or its muscles. The posterior portions of the free clypeal border on each side become more or less laminiform at the lateral clypeal angles, where they finally merge more or less completely and indistinguishably with the *preocular laminae*. The latter structures have been known as "ventrolateral borders" or have been described in other ways by former authors, but it should be noted that the laminae are quite distinct from the true ventrolateral borders, which are usually the same as the ventral borders of the antennal scrobes in the anterior region of the head. This point is fairly well illustrated in the lateral view of *S. rostrata*, text-fig. 2, taken from Smith's synopsis of the Nearctic ant genera. Kennedy and Schramm (1933) show the relationships of the various borders very well and in some detail in their figs. 1-8. The preocular laminae become narrower posteriorly, and finally disappear somewhere in the neighborhood of the dorsal side of the eye, the latter organ being situated on the dorsal side of the ventral scrobe border, usually at about the cephalic midlength. The eyes are usually poorly, and never really strongly developed and have 2-9 facets in their greatest diameters. Figs. 5 and 6 of Kennedy and Schramm illustrate very nicely variation occurring in the workers of one nest of *S. dietrichi* with regard to medial or lateral displacement of the eyes; this variation must be considered in the determination of species in any part of the genus.

The mouthparts are quite aberrant and of great interest both taxonomically and morphologically. Those of the Nearctic *S. dietrichi* were studied in considerable detail by Kennedy and Schramm (1933); it is stated in footnote 1, page 95 of their paper that "Kennedy is responsible for the general and morphological notes, also for the illustrations," so that references to statements and illustrations in the paper will be given here under Dr. Kennedy's name. The mandibles are the largest and most conspicuous parts and are of great importance due to variation by species or species-groups in the dentition. While small in comparison to those of most *Strumigenys* species, the mandibles are rather large and prominent in comparison with those of ants of many other tribes; furthermore, their seeming small size is partly due to the fact that in the normal closed position up to one half or even more of the full

length may be concealed beneath the clypeal apron. The mandible freed from the head is seen to be narrowly subtriangular in dorsal view. Several of the figures in Plates I and II (figs. 11, 12, 17, 19, 21, 24) show the mandibles of their respective species in dorsal view, and due to the transparency of the integument, the dorsal and ventral views are much alike. A study of these figures will show that the shaft is a long, thin, hollow shell with a U- or C-shaped cross section along most of its length. Kennedy's figures 8 and 13 show this correctly, although several of his other figures are ambiguous or incorrect in demonstrating this point.

In normal position as attached to the ant, the hollowed-out face of the mandible is directed inward and downward, and the lower of the two mandibular margins is ventral and out of sight when the head is viewed from above; this lower margin may be called *ventral margin*. The upper or *dorsal margin* is divided into two borders, a tooth-bearing *apical border* (inner or masticatory border) and a more or less oblique, concave *basal border*, the two borders meeting through an obtuse angle capped by the *basal lamella*. In practice, it is also convenient to term the lateral profile of the mandibles as seen in dorsal view "lateral margin" or "external border," even though a true border or margin is not present here. The basal lamella varies enormously in shape from species to species, as will be appreciated from the plates. In some of the figures it appears much like just another tooth of the apical series; in others it is seen to be more or less fused with the first few apical teeth. In actual specimens mounted in balsam, however, it is seen to differ from the apical teeth in its thinner texture and in the fact that its proximal border is continuous with the basal border. In quite a few species it is separated from the *apical series* of teeth by a greater or lesser *diastema* (figs. 1-3, 7, 16).

The teeth of the apical series vary with species in shape, relative size and in numbers. The basic number appears to be twelve, and there is no species known to me that has more than twelve. Certain species have lost one, or rarely two or more teeth by reduction or fusion; stages in this lessening of the number of teeth are illustrated by figures 2 (reduction) and 15, 17 (fusion). *S. (Platystruma) depressiceps* seems to have undergone the most radical reduction (fig. 18) by fusion. The apical series is conveniently subdivided according to the size of the teeth into *principal* (basal), *intermediate*, and *preapical* series, and an extreme *apical tooth*. The principal series consists of the large teeth, usually five in number, nearest the base. The intermediate series consists of two teeth, often intermediate in size, but really scarcely differentiable from the principal series; distal to these and just before the apex comes the series of four preapical denticulae, usually very small and the most constant series in size, position and number. The single apical tooth is variable in size and often small, but usually larger than any of the preapical denticulae. Very many specimens have been examined for mandibular characters during the course of this work, but only three cases were noticed of inconsistent dentition among the material; two specimens of *S. clypeata* (of 22 examined) showed a supernumerary denticle as portrayed by the dashed line in fig. 16, and one specimen of *S. ornata* (of 26 examined) as in fig. 2. The various combinations present are beautifully adapted as specific characters and will probably show a great deal concerning phylogeny to future workers with better

collections. Unfortunately, dissection of the mandibles usually means destroying or damaging the specimen, so that in cases where type series were very small and belong to other persons or institutions, I have not risked the proper examination of the dentition.

The labrum is highly modified in all *Smithistruma* and more or less resembles Kennedy's figs. 8 and 9. Kennedy shows the apices of the labral lobes as a bit more acute than they actually are and omits the hairs which spring straight forward from the tips. One of the hairs on each apex is longer than the others, but never nearly so long as the corresponding "trigger hairs" of *Strumigenys*. The labrum consists essentially of a pair of close-set, parallel, elongate cones, basally slightly broadened and with the basal portions attached by a transverse body or partition. In specimens of several species examined under the compound microscope after being placed uncleared in damar, air bubbles were seen to fill the lumen of one or both cones. Pressure on the cover glass caused the bubbles to be squeezed out through what appears to be an apical or subapical orifice on each lobe. Whether or not the orifice was natural or was an artifact in each case could not be certainly determined. If the orifice is natural, there exists the possibility that the labral lobe acts as a nozzle in ejecting some toxic or other substance used in quieting the prey. Another possibility is that the lobes may somehow be used as sucking mouthparts in obtaining food. In many mounts, there appeared to be an orifice, perhaps again an artifact, in the transverse body between the two lobes near their bases. If this is a real and constant feature, one might suppose that a purpose of the lobes would be to act as a guide or track between which liquids could either be ejected or drawn into the mouth cavity. The mouthparts are so small and heavily chitinized that brief attempts on the part of Dr. John Woodland and Dr. William Nutting to investigate the structure by means of serial sections met with no success. The purpose of the very aberrant labral apparatus therefore remains obscure, and the speculation indulged in above is intended only to stimulate further investigation.

The maxillae are shown in Kennedy's figures 7, 8 and 12. These figures are very clear as far as they go, and figure 8 shows nicely how the mouthparts appear closed and in the protective position in which they are found in most specimens killed in alcohol. Unfortunately, Kennedy has overlooked the lacinia, which he definitely states he did not find. In workers of *S. rostrata* (Tennessee), *S. pergandei* (Ohio) and *S. dietrichi* (Tennessee) examined during the course of the present work, the mouthparts of three specimens of each species were mounted in lactic-acetic acid medium and examined under the compound microscope. In all cases the lacinia was clearly present as a sub-quadrate plate of thin, transparent, chitinous-appearing material situated in the usual position. I have checked my slides against the figures presented in the masterly survey of formicid mouthparts by Bugnion (1930), and there is no doubt that the lacinia has been correctly identified. This member corresponds in position to the appendage shown unstippled in Kennedy's fig. 12, and since I can think of no other structure that would occupy the same position in that author's *dietrichi* specimens, it appears that he has drawn in the lacinia in a vague way without realizing what it was. The figure in question shows the proximal border as oblique and representing a torn, or perhaps jagged edge.



In all of my specimens, the medioproximal angle of the lacinia is rounded and the proximal border transverse, the angle bearing the majority of the hairs found on the border of the lacinia concentrated into a small row or brush. I believe that Kennedy mistook this row of hairs for the torn edge of an unidentified membrane.

Otherwise, Kennedy's fig. 12 is clear and accurate, showing the cardo, stipes, epistipes (supporting the lacinia), palp and features of the galea. It may be mentioned that the two longest hairs on the galea are relatively thicker in all three species examined than as shown in Kennedy's figure, and the apices of these heavy hairs are slightly thickened and sharply recurved. The palps are worthy of note, since they are reduced on each maxilla to a single very small, subfusiform segment bearing a slender apical seta. The structure of both labial and maxillary palps is about the same in all the species of the *Strumigenys* complex (including about half of the *Smithistruma* species discussed in this work) in which the mouthparts were readily accessible to examination *in situ*. I have little doubt that this is a constant generic character.

The labium is similar in structure to that of most other ants in possessing submentum, mentum, striated glossa and rastelli; the palps are present as small, stout, single-segmented curved clubs, a little larger than the maxillary palps. Kennedy shows all of these parts faithfully except the rastelli, which are so large and prominent that this omission is unaccountable. The epimental rods are present but small, and though not homologized, are shown in Kennedy's figs. 10 and 11, Z. The raquettes are large and rather shapeless, appearing membranous in my preparations; Kennedy does not show these in his figures.

The antennae, as in other dacetine ants, vary in length with the amount of anterior extension of the mandibles. Accordingly, those of *Smithistruma* are rather short. The funiculus is always longer than the scape; the latter is feebly to strongly incrassate and weakly to very distinctly bent or curved near the base. The funiculus is made up of five segments proportioned as in the majority of *Strumigenys* species, i.e., the apical segment forms a long thick clava slightly to distinctly longer than the four basal segments taken together. Segments II and III, counting from the basal segment, are very small, often transverse, and in the *baudueri* group are indistinctly separated from one another and from the basal segment, giving the distinct impression that fusion is in process. Segment I is slender and cylindrical, but short, usually as long as II + III and equal to or a little longer than IV in length. IV is rather broad and may in a sense also be taken as part of the apical clava; it is usually longer than broad, but in very short-mandibulate species may be slightly broader than long.

The alitrunk (equivalent to the "thorax" of most writers on the ants) is composed as usual of the true thorax immovably fused with the propodeum ("epinotum" of some authors). All the elements of the alitrunk are solidly fused dorsally; sutures here are obsolete or obsolescent in the worker. The promesonotum usually forms a single convexity of greater or lesser degree, the pronotum being the widest part of the alitrunk. The mesonotum is usually considerably narrowed and often depressed toward its posterior extremity; it is limited at the rear by the usually obsolete or very feeble metanotal groove



(called "mesepinotal suture" or various other names by different workers). The propodeum and elements of the metanotum together form a rather narrow box, usually with the sides subparallel and more or less continuing the posterior surfaces of the mesopleurae. The propodeum possesses dorsal ("basal face" of authors) and declivous faces, usually forming a more or less distinct angle where they meet as seen in lateral view. The dorsum is plane or weakly convex, and seen in profile is usually continuous or nearly so with the posterior dorsum of the mesonotum, there usually being little or no interference with the outline by the metanotal groove. Propodeal teeth are always present and distinct, usually acute and more or less compressed, and continued ventrally by infradental lamellae or cariniform lamellar vestiges; both the teeth and the lamellae vary greatly in development, shape, etc. according to the species. The lamellae may be convexly broadened or subangular at their ventral extremities, but they do not form prominent acute teeth here as in some other genera; often the lamellae or carinae will just gradually disappear ventrally. The sides of the alitrunk bear a distinct suture between the lateral plates of the pronotum and the mesopleurae; this suture runs vertically from near the spiracle hidden just under the edge of the lateral pronotal plate down to a small aperture situated just behind the anterior coxae; this aperture is round or oval, and constitutes the lateral opening of a deep transverse groove traversing the sternum; each aperture may be surrounded by a thick growth of very fine short hairs, so that it may have some glandular function in certain species. There is also a more or less distinct furrow separating the meso- and metapleurae for a distance ventrally from the metanotal groove. The spiracle on the metapleural-lateral propodeal face is quite prominent, and the metapleural gland is present in the posterolateral part of the metapleural extension as a more or less translucent swelling with a posterior aperture.

The "neck" forming the actual attachment between the pronotum and head is usually separated from the dorsum of the pronotum by the arcuate, sharp anterior pronotal border, although in some species this border is absent or reduced.

The petiole consists of a cylindrical or subconical peduncle and a distinct node, the latter with a more or less rounded summit and often with a feeble carinula running from the summit down each side of the anterior face onto the peduncular dorsum. Spongiform appendages are usually present (sometimes vestigial) as a posterior transverse dorsal collar with lobes more or less developed from its ends on the sides of the node; the midventral strip may be present and well developed, or in the *schulzi* group, may be completely absent.

The postpetiole is transversely ovate or elliptical, broader than the petiolar node, with a convex dorsal surface. Spongiform appendages are always present, but vary greatly in development from species to species.

The gaster moderate to small in size, ovate, more strongly convex ventrally than dorsally and with a more or less pointed apex. The anterior dorsal border is transverse and usually fitted with a spongiform margin, and an anteroventral pad consisting of a spongiform mass and some fine subreclinate hairs is usually present but more or less covered by the ventral postpetiolar appendages. The spongiform appendages are chiefly or entirely formed of

areolate and vesiculate, finely involuted and subdivided lamellar chitin or whatever material the integument itself is made of. The function of these appendages is at present entirely unknown, although it may be that it has something to do with luring collembolan prey within striking distance through some sort of olfactory principle postulated as being connected with the appendage. Certainly these structures, appearing in over two hundred related species of higher dacetine ants, must have some important function in the economy of the insects.

The sculpture is basically the same as in *Strumigenys*, consisting on the head and alitrunk of crowded, very fine punctulae; each of the punctulae under very high magnification may be seen to possess a small central tubercle bearing a hair or the vestige of a hair. While the punctulae are very greatly reduced in size and enormously multiplied in numbers, the plan of each of the units and the general relationships of one to another are essentially the same as found in lower genera like *Acanthognathus* or *Hexadacton*. The spaces between the punctulae in *Smithistruma* are opaque in general, and in any case are so narrow that little light can be reflected from them. The scapes, legs and petiole are most often also punctured in the same way or more finely so, but usually not so distinctly as is the head. The postpetiole may be smooth and shining or punctulate, while the gaster is most often smooth and shining over the major part of its surface. At the base of the gaster are found a number of basal costulae ("striae" of authors) in the nature of fine or coarse, somewhat thread-like structures extending from the spongiform anterodorsal border back over the surface of the basal gastric tergite for varying distances. These appear as anchoring devices for the spongiform border, but this may not be their function.

The sculpture, of course, varies greatly with the species, and practically any portion of the body may have the punctulation wholly or partly effaced and the resulting surface more or less smooth and shining. Also, there may be longitudinal rugulation or striation present in varying degrees of distinctness, especially on the pronotum and postpetiolar disc. The major portion of the head capsule, however, seems always to retain its punctulation in about the same way. The mandibles are usually more or less smooth and shining. The alitrunk usually shows a number of small surface features, such as humeral and lateral mesonotal paired piligerous tubercles, and these are relatively constant in position. Other piligerous tubercles may also appear in pairs. There is quite often a median longitudinal carinula on the promesonotum as in many *Strumigenys* species.

The pilosity of *Smithistruma* is very important in taxonomy, since the species vary widely from one to another in respect to the form and development of the different hair systems. The fact that there exists a basic pattern upon which the hair systems vary does not appear to have been properly recognized; this pattern is apparently the same for *Strumigenys* and *Smithistruma*, and the two genera display perfectly bewildering modifications in parallel development that show that the pattern of genetic control must be very similar throughout.

The hairs may be divided into three "systems" or kinds of pilosity, any one of which may be masked by submergence in another system:

(1) *Ground pilosity.* Pilosity analogous at times, but probably not homologous, to the pubescence of other formicid tribes. The term is here reserved for the relatively short, numerous hairs of the head and alitrunk, usually appressed or subreclinate, and the smaller reclinate hairs of the legs. These hairs are varied in form, and may be filiform, spoon-shaped, spatulate, etc. They are usually more abundant and larger on the head than on the alitrunk, and those of the occipital region tend to be longer and narrower than those on the anterior part of the head. The petiole, postpetiole and gaster rarely bear well-defined ground pilosity.

(2) *Border pilosity.* The free clypeal border and the anterior borders of the antennal scapes usually bear a kind of specialized ground pilosity in the form of a row or fringe of hairs. These are usually larger than the rest of the hairs on the surfaces of clypeus or scapes respectively, and may be curved in various directions.

(3) *Specialized erect hairs.* These hairs, when present, are longer than the ground hairs and more slender and erect. They may be clavate, spatulate, bristle-like or flagelliform; they seem to be distributed in a basic spatial pattern. The basic pattern seems to include two transverse rows of four each on the verticociput, the two most lateral hairs of the anterior row being situated on the sides of the occipital lobes and directed laterally. The median pair of the anterior row is quite often absent in the worker. Each humerus and each side of the mesonotum usually bears one of these hairs, and there may be one or two extra pairs present also on the alitrunk. These usually arise from the piligerous tubercles mentioned above. The petiolar node may bear one or two pairs, directed posteriorly, and the postpetiole 2-4 pairs, also directed to the rear. The gaster bears 2 to 7 more or less irregular transverse rows, usually of 4 hairs each. The anteriormost row may be inclined anteriorly or posteriorly, but the rest are usually inclined posteriorly; the hairs become shorter and finer toward the apex of the gaster. Any of the hairs mentioned in this system may be absent, and sometimes all of them are merged into the ground pilosity; the limits between the two types of hairs are frequently academic.

The range of coloration shown by the genus parallels that of *Strumigenys*. The basic pigmentation appears to be a kind of reddish-brown or orange-brown usually known as "ferrugineous." The differences in color from one individual to another seem to be due to variation in the degree of concentration of this pigment more than to addition of other pigments, even though certain forms may be so dark as to approach blackness. Accordingly, I have usually stated color in terms of degrees of ferrugineosity. Since variation in one species or even in one nest may be considerable, color is not usually considered to be a very significant taxonomic criterion. Nevertheless, it is sometimes of importance as a specific character in known material. Variation known to me in the worker caste ranges from pale ferrugineous yellow to blackish-mahogany; I have never seen a jet-black individual. The majority of species are concolorous or nearly so, although the gaster and sometimes the cephalic dorsum may be slightly infuscated. The legs and other appendages of relatively small mass usually appear lighter than the rest of the body, but this is probably due

more to the translucency of the members than to a lesser concentration of pigment there.

The total length of *Smithistruma* workers I have seen varies from about 1.5 to 2.85 mm. The head varies from a little more than half as broad as long to less than 9/10 as broad as long. The mandibles are usually less than 1/4 the length of the head proper, considering only their normally exposed length, and are most often decidedly shorter than the clypeus. In a few forms, however, the mandibles reach almost 1/3 the head length and are as long as or very slightly longer than the clypeus. The head and alitrunk are usually not very different in length, and quite often are just about equal, though the length of the alitrunk is more variable in any given species than is that of the head. The legs of *Smithistruma* are usually of moderate length, and the whole animal gives an impression of compactness. The tibiae are rather short and incrassate, especially toward their apices. A well developed sting is present in all the species so far as I am aware.

*Female:* The female differs from the worker in much the same way as in *Strumigenys*. The total length and the widths of head, alitrunk, petiolar node and gaster are usually greater than in the worker, but the difference, while usually constant in one species, is not so great as might be expected from the experience of caste differences in other ant tribes. The eyes, of course, are much larger and more convex, and ocelli are present and well formed, but rather small. The wings are always developed, and consequently the alary sclerites of the thorax are fully differentiated, changing the form of the alitrunk completely from that as seen in the worker. Forms intermediate between worker and female are unknown. The scutum often bears the median carinula seen in the worker, and in addition, the surface may be finely longitudinally rugulose or striate. The scutellum is distinct and often convex or projecting behind. The propodeal teeth are usually lower and broader than in the worker. The mesopleurae tend to be smooth and shining even when opaque and punctulate in the worker. The enlarged mesonotal dorsum quite often bears additional ground pilosity of the same type as is found on the head, and also some specialized erect hairs like those found elsewhere on the body. The color may be as in the worker, but usually is a little darker.

The wings are as in *Strumigenys*; in all cases the venation of the forewing is very much reduced, the species showing further reduction paralleling that seen in *Strumigenys* species. The most frequently well developed elements remaining are  $R + Sc$ , stigma,  $2r$ ,  $M + CuA$ ,  $CuA$  and "basalis" ( $Rsf1 \cdot Mf1$ ). The others are usually present only as ill-defined grooves or are entirely absent. The posterior wing is long and narrow, with the long bordering microtrichia posteriorly as developed in other very small ants; only one poorly defined vein present in the basal half of the costal region. Hamuli 4 in number, weak, decreasing in length from base toward apex, placed a little beyond the midlength of the costal border in a close series.

*Male:* Relatively few of the males are known. They are usually larger than the workers, but slender, and not so large as the female. The head is much reduced and more normal in shape, much like that of other myrmicine genera, with a robust inverted-teardrop shape. The eyes are very prominent, large and convex, situated well in front of the middle of the head and usually

close to the mandibular insertions. Mandibles degenerate, usually but not always lacking serial dentition; in closing, the apices may or may not meet. The under-mouthparts are large by comparison, and the mandibles are shorter, or at least not greater in length than the greatest diameter of an eye. Notauli and parapsidal furrows are present on the mesonotum, but are variably developed, the former especially often disappearing before reaching the postero-median point of juncture. The propodeal teeth and infradental lamellae are more or less strongly reduced. Petiole and postpetiole low and gently rounded, usually smooth and shining dorsally, as in the gaster. The basal gastric costulae are usually absent, rarely present but vestigial. Spongiform appendages are often present as vestiges, but are rarely anything like as well developed as in the worker. Antennae 13-segmented, the scape very small, not or only slightly larger than the remainder of the segments. Genitalia formed into a compact, usually retracted capsule, the individual parts much as in *Myrmica*. The volsellae appear to vary with species or species-groups, but so few have been figured that it is difficult to follow relationships by means of these structures. The volsella (see Plate III) consists of a large digitus with an arm placed at a right angle to the body, a smaller cusp, seemingly firmly fixed and flattened, placed at the side of the digitus. There is also usually present an angle or point, bearing a number of hairs and projecting ventrally from the base of the digitus so as to oppose the tip of the digital arm. The hairs are not shown in the plate given here, but they may in the future show characters of importance in their arrangement and relative lengths. The angle or point mentioned seems to be rather constant in many myrmicine groups, and it may be termed the *piliger*, since no one seems to have put forward a name for it to date. The relative sizes and shapes of these various parts seem to furnish the best characters for recognition, together with the mandibles and eyes.

The sculpture is in general like that of the worker, but with more smooth areas; sculpture and development of propodeal spines may vary considerably even among the individuals of one nest. Pilosity is reduced and usually very fine, lacking most of the bizarre elements that may be seen in workers and female, although there are often long, fine hairs present in positions corresponding to those of the specialized erect hairs in the female castes. The color is darker than in the worker, the head and often the thoracic dorsum being close to black in some species, while the remainder of the body is mostly deep castaneous or other shades of brown. I have yet to see any individuals that were jet-black. The male caste has been very much neglected in the systematics of the group, and even when descriptions have been set forth, the essential characters of the mandibles and volsellae have only very rarely been described. It is very possible that other parts of the genitalia, such as the serrate-edged aedeagus or the parameres, will show characters as good or better than those of the volsellae, but this will require many specimens and more time for refinement of techniques than I could allow during this work. Eventually, we will probably need to know the male characters in order to answer otherwise imponderable questions of phylogeny, and this is the chief importance of the caste to the dacetine systematics. It is at present impossible to state a general character that will separate the members of the caste from one

higher dacetine genus to another, although it is frequently possible to recognize the species.

#### BIOLOGY

The very interesting and specialized habit of feeding upon Collembola appears to be widespread in the genus, at least in the Nearctic Region, and this has been discussed elsewhere. There remain a number of generalities that can be made concerning general ethology and ecology, although the data for regions other than North America are exceedingly rare and vague. The genus is usually associated with a rotten-log habitat by myrmecologists, for it has been in such places that a large number of the forms are habitually collected. Recent evidence in the form of Berlese funnel samples of forest floor and even rich, grassy, open areas, however, indicate that the number of forms to be found living in the soil or soil cover proper may be much greater than that of forms preferring rotten logs. Furthermore, as will be discussed later, there is a very rich dacetine fauna, but one now virtually unknown, that is partial to arboreal or subarboreal existence in epiphytes or other plant cavities. Several forms, especially the tramp species of the higher dacetines and including at least two *Smithistruma*, exist very well in relatively dry and inhospitable climates. One can say only that available collections, and these quite scarce, tend to show that *Smithistruma* is best adapted in general to a life in forested regions with a mild climate. It is probably much more to the point to say that most or all species are limited first by the abundance of suitable collembolan prey and then by temperature.

The colonies are usually small, rarely containing over 300 workers as presently recorded, but even relatively small nests are usually pleometrotic. The nest is a small chamber, oval in shape, but is usually much larger than would seem necessary for containment of the adults and brood. Furthermore, there may be one or two other similar chambers placed within a short distance of the brood chamber, but the latter usually contain only a few adult ants. Many possible uses of such a chamber in capturing springtails come to mind, but there are no observations of any concrete sort to bolster any kind of speculation at present concerning the function of the cells. The nests may be built in soil cavities, in or under rotten logs, under stones, in small twigs, nuts, etc., etc.

The larvae are whitish in color and rest motionless or nearly so in the brood chambers. They are well cared for by the workers, which feed them at least part of the time by placing them directly on top of freshly-killed springtails. In my particular colony of *S. rostrata*, I never once observed regurgitation from worker to larva, but since my colony did not seem very healthy or vigorous, I would certainly not say that the larvae are never fed by regurgitation in nature. I have not attempted to examine the morphology of the larvae, but have been accumulating larvae of various species to send to Dr. G. C. Wheeler, who has been conducting a morphological survey of the larval formicids tribe by tribe. He can undoubtedly examine these forms more efficiently than I can in relation to other groups.

Solitary females have been found isolated in chambers of much the same size occupied by the brood of a mature colony; although I know of no cases where such a female was found definitely accompanied by eggs or brood, I

assume that these individuals were founding nests in the usual way. No parasitic forms of *Smithistruma* are known definitely to exist, but it would not be surprising to find that such forms do occur. Certain species of *Smithistruma* commonly nest or forage in the chambers of other kinds of ants, and they apparently choose such a habitat because of the large numbers of collembolans often swarming in formicaries.

The nuptial flight has not been observed for any species, but it is known from accumulated evidence to occur at the end of the summer in temperate North America.

Because of their extremely slow-motion, deliberate movements in locomotion, their small size and their coloration, as well as their frequent habit of feigning death when disturbed, individual workers or colonies of *Smithistruma* are very difficult to locate. Once one has acquired an eye for them, however, they may be found very abundant in favorable areas. In south-central Ohio, the Wessons commonly found as many as fifteen or twenty nests in a single day's collecting. Berlese funnelling by the staff of the Illinois State Natural History Survey in the course of a general insect survey, and similar work in Collembola-rich areas of North Carolina by Dr. D. L. Wray show that *Smithistruma* is widely distributed and common throughout much of these states. They are, of course, absent or very rare in true desert areas where the collembolan fauna is reduced, and there are many apparently favorable areas within their range where one cannot find them by any method. For more detailed accounts of biology, it is suggested that the works of the Wessons be referred to.

#### DISTRIBUTION AND REMARKS

The known species of *Smithistruma* (56) probably constitute less than a third of the existing species. Therefore, any generalizations of a zoogeographical nature must remain tentative. By major regions, the number of known species is as follows:

Nearctic*	23	Temperate East Asian	2
Neotropical†	14	Indomalayan	6
Ethiopian	4	East Papuan	0
Malagasy	0	West Papuan	1
Mediterranean	3	Australian	0
Oceanian	2		

\* Not including *margaritae*. † Including *margaritae*.

No species are known from Chile, New Zealand, or the Holarctic Region very far north of 45°N. The Nearctic and Mediterranean Regions are well known and are not expected to yield very many new forms. Large numbers are expected from Neotropical, Indomalayan and Temperate East Asian Regions, since these regions have scarcely begun to be properly explored. The African continent south of the Sahara certainly contains more species, but here the numbers seem to be limited, probably by competition with *Serrastruma*. Compared to the genus *Strumigenys*, which seems to be about similarly well collected and which contains roughly three times as many species, the distribution of *Smithistruma* shows greater strength in the Temperate Zones. In Europe, no species of *Strumigenys* occurs at all; in the Orient,



one species (*Strumigenys lewisi*) is found north to near 40°, and another rarer species (*solifontis*) inhabits southern Japan; in North America only one primarily Neotropical *Strumigenys* occurs, and this probably does not reach 40°N. Only three species of *Strumigenys* are known from between 30° and 40°N., while this same belt supports 28, or 50% of the known species, of *Smithistruma*.

Biologically, one might say that *Smithistruma* is a rather inefficient predator. This may be even more true when thorough comparisons can be made against *Strumigenys*, as observations of Wilson (in litt.) suggest. In other ways, however, *Smithistruma* is better suited to life in cooler climates, or at least many of the species are, in comparison to the overwhelming majority of *Strumigenys* species. *Smithistruma* in North America shows rigid adherence to a seasonal cycle in the time of nuptial flight and in other habits, while *Strumigenys louisianae* in North America follows the cycle in a much more erratic way. These facts seem to show that the Temperate Zone *Smithistruma* in North America behave as though well-acclimatized, while the single *Strumigenys* species, which has its main range in the Neotropical Region, does not. Other evidence shows that *louisianae* is a rapidly expanding species which has relatively recently entered the North Temperate as well as the South Temperate Zones. It has many very close relatives in Central and South America, mostly undescribed at present, but represented in my working collection, and it is more variable nearer the center of its range (South America) than in North America. Much of the same situation exists in Temperate East Asia, where the two *Strumigenys* species, while known only from temperate regions, belong to the rapidly expanding and dominant *godeffroyi* group. The *godeffroyi* group otherwise consists of a large number (about 30) of very closely related tropical Indomalayan species.

While the three major *Strumigenys* faunas (Neotropical, Ethiopian, and Indo-Australian) show little close relationship to one another, the *Smithistruma* species of all continents seem much more closely related. These relationships are pointed out in another section, where it is noted that an especially close one exists between the faunas of eastern North America and temperate East Asia. All this indicates that *Smithistruma* was (1) more recently evolved than *Strumigenys* and (2) that at least the North American species of *Smithistruma* are derived from ancestors that crossed the Northern Filter Bridge from Asia later than the last contact occurred between any of the three major *Strumigenys* faunas.

Thus, it appears that while *Smithistruma* has proven relatively inefficient as a predator, it has been able to exploit resources in the form of the swarming collembolan populations of the North Temperate Zone and thereby avoid the areas where the more efficient hunters held sway. I think, after reviewing the possible relationships of the groups in the various faunal regions, that *Smithistruma* must have had its origin from *Strumigenys* or a genus closely related to *Strumigenys* somewhere in the Old World, possibly in Africa. The African species are little known, but from the diversity of the four recognized species, one can see that the continent must have supported a large and varied fauna in the past, a fauna now being decimated by the dominant African dacetine group, *Serrastruma*. *Serrastruma*, in turn, appears to have been

derived from *Smithistruma* or a *Smithistruma*-like form within the African continent, and this now dominant genus seems to have begun its spread from Africa outward. It has occupied Madagascar and the larger islands in the Gulf of Guiana, and has reached Mauritius and even the shores of Hawaii as stowaway cargo in human commerce. Within the African continent south of the Sahara, *Serrastruma* shows its vigor by reaching high altitudes in the cool, wet mountains of East Africa and by its successful occupation of relatively arid regions in South Africa and Nigeria; it is abundant in species and individuals in the Congo rain-forests.

I mention the present state of affairs with regard to *Serrastruma* in order to illustrate the possible way in which *Smithistruma* arose, gained dominance and adaptability to climates and moved outward to begin a steady colonization of the world. This colonization has been interrupted by the glaciations and has not proceeded for a long enough time to allow *Smithistruma* to reach extreme limits reached earlier by *Strumigenys* in Australia, New Zealand or Papuasia, where water barriers form formidable obstacles to the weak-flying, deciduous-winged females. One or more waves of migration have carried *Smithistruma* to North America and beyond; it appears in the form of three known species in the relatively temperate area in southern Brazil and northern Argentina, and is apparently at home in arboreal situations in the cool cloud-forests of northern South America; at least three species have become adapted to true tropical conditions and presently challenge even the dominance of the ubiquitous *Strumigenys louisianae* within its home range.

In this discussion, I have borrowed heavily from the ideas put forward by Darlington (1948) in his study of the distribution of the cold-blooded vertebrates. While I realize that I may be chasing my theoretical tail, I must state that from the present evidence, incomplete as it may be, Darlington's argument fits *Smithistruma* and *Smithistruma* fits Darlington's argument. Furthermore, both arguments fit the strong morphological evidence that *Smithistruma* has been derived from *Strumigenys* or something very close to *Strumigenys*.

#### NEARCTIC SPECIES OF SMITHISTRUMA

In North America, there occur 24 known species of *Smithistruma*, including two that fall in the subgenus *Wessonistruma*. *Wessonistruma* is indigenous to the continent. Of the 22 species of *Smithistruma* s. str., *S. margaritae* belongs to a Neotropical group and has its main range south of the United States. *S. (W.) pergandei* is the only species known from Canada, and even this species just barely manages to reach the border on some small islands in Lake Erie. Only one species, *S. californica*, is known from west of the Great Plains, and this Californian species may represent an introduction. Nevertheless, there are other indications, discussed farther below, that *Smithistruma* may occur in the Pacific Northwest.

By elimination of the exceptions, one sees that the genus as found in North America is by far best developed in the temperate forest regions of the eastern United States from the Great Lakes to the Gulf of Mexico. Within this region many species of the genus are often common, but due to their small size and cryptobiotic habits they are not familiar ants even to many myrme-

cologists. The discovery by L. G. Wesson that certain species feed exclusively or nearly exclusively upon Collembola has raised a great deal of interest in the United States, so that many students have started collecting them. Due to this fact and also to the increased use of the Berlese funnel in general entomological collecting, the records have increased during the past ten years out of all proportion to the previous rate.

Fortunately, due to the excellent and temperate taxonomic work of Dr. M. R. Smith and the Wessons, the systematics of the Nearctic species has kept pace with the biological findings. In comparison with other faunas, this one is excellently known and in need of little adjustment.

Except for *S. margaritae*, all the Nearctic species are related in that the workers and females have the basal mandibular lamella acute and dentiform. Even *Wessonistruma* seems to be only an extended aberrant stock closely related to certain of the other sympatric species. The closest relationship of the whole fauna seems to be with that of Japan and China, since closely similar members of the *rostrata* group occur in these temperate Oriental Regions. A more uncertain relationship occurs through the *rostrata* group with species like *orchibia* of the Neotropical Region. *S. margaritae* has almost certainly invaded the United States within comparatively recent times. It acts suspiciously like a tramp species in its occurrence about port areas and in the West Indies, although there is a possibility that its original range did run up the Texas coast.

Due to the former competent coverage of the taxonomy, I have been as brief as possible in my characterizations of the species. The descriptions are usually limited chiefly to corrections of minor errors in former works, to description of sexual forms not formerly reported upon, and to more thorough characterization of features in the worker caste which do not seem to have received the proper attention. I have included figures of many of the mandibles, since these have not formerly been very well attended to, and also representative male volsellae. The best of Dr. Smith's figures are included with his kind consent and aid in order to give an idea of general habitus in some of the groups.

The best former references are those of Smith (1931), L. and R. Wesson (1939) and Emery (1895). Dr. W. S. Creighton has also covered the group in his book on the ants of North America, the publication of which is expected momentarily as this is written. Dr. Creighton's work has been so long in the preparatory stage that he has not been able to include the changes of names among the genera as I have recorded in my original generic revision; therefore, he still has (at least in the manuscript now with the printer) all of our North American species placed, as Smith left them in 1947, under *Strumigenys* (*Trichoscapa*). I have read the manuscript and discussed it at length with Dr. Creighton, and I know in detail his opinions on the various species of our fauna. Due to the fact that the book has not been published at this date, I cannot discuss these opinions here; nevertheless, I think I have covered sufficiently the evidence for my placement of species where Dr. Creighton's treatment differs. I am satisfied that the present treatment of the various forms is the best that I am capable of on the basis of the available material and after the consideration of the opinions of all other North Amer-

ican specialists brought to my attention. The study material includes the great majority of specimens available to all former North American myrmecologists plus a number of more recent collections greatly exceeding the total number previously published upon and embracing wide areas from which few or no dacetines have hitherto been reported.

I am especially indebted to Dr. M. R. Smith of the United States National Museum for his constant and patient aid in the matter of material and advice. Any success which this section of the revision may enjoy is due in large part to his efforts. Many other individuals, especially Mr. L. J. Stannard of the Illinois State Natural History Survey, Dr. L. G. Wesson, Dr. D. L. Wray, Mr. E. O. Wilson, Dr. Mary Talbot, Lt. J. W. Jones, Jr., Dr. A. C. Cole, Jr., Mr. D. W. Pfitzer and others mentioned in the list of acknowledgements at the beginning of this work have sent large series of specimens with extremely full and valuable ecological data, making it possible to give general statements concerning the biology of many species.

The taxonomy of the Nearctic species, while considerably better known than that of other faunas, still leaves plenty of room for improvement. Several forms, such as *brevisetosa*, *pilinasis*, *reflexa*, *missouriensis* and perhaps one or more of the new species I have recently described are known from too few collections for final judgments concerning their status. There is little doubt that another decade will bring changes among these forms as regards synonymy and decisions on possible geographic races at present unrecognized. Furthermore, there are almost certainly a few more species remaining undescribed. Exploration of the grass-tussock and epiphyte faunas in the Gulf State area should reveal new forms, and Cole's lost species remains to be rediscovered in northern California, possibly accompanied there by still other unknown species. The fauna of the moist and temperate parts of Mexico remains completely unknown, but some species either of Nearctic or Neotropical groups must occur in that region. *Smithistruma* should be looked for in any habitat south of the Canadian Border that supports an abundant collembolan population.

The biology of the Nearctic species has been covered in some detail in the works cited above, and several other writers have given details of nesting habits for occasional species. Nearly all of the really common species of both subgenera occurring in the region are known to subsist chiefly upon Collembola, which creatures they capture alive by the employment of stealth and possibly also by the aid of the bizarre pilosity and spongiform appendages so characteristic of the *Strumigenys* complex. Much remains to be understood about the means by which the prey is captured. There is now little doubt remaining that at least some species show a high degree of selectivity in choosing prey from among the various families of Collembola; springtail species with a well developed springing apparatus or furcula seem to be preferred, while species lacking the furcula so far tried have usually been shunned as prey by the ants. Mr. E. O. Wilson of the University of Alabama is presently engaged in intensive studies of the feeding habits of this and other dacetine genera occurring in the United States. He has already made many very interesting observations that will undoubtedly, when published, give us a clearer picture of dacetine biology.

Up to the late 1930's most of the *Smithistruma* species described from the United States were those found in rotten logs and stumps, but with the work of the Wessons in southern Ohio and the flood of Berlese funnel material that has begun to arrive on the desks of myrmecologists, it has become increasingly clear that there exist a number of species restricted in habitat to the soil cover, often in quite open, grassy areas distant from forest growth. Such species are *ohioensis*, *talpa*, *ornata* and probably some of the species, including *bimarginata* and the new forms, that are known only from one or two collections. Other species like *dietrichi* and probably also *pulchella* and a few others, appear to be restricted entirely or almost entirely to nest sites in large masses of rotten wood in the form of logs, stumps or rot-holes at the bases of trees. A large number of species, as might be expected, will nest in either habitat without apparent preference; among these are members of the *clypeata* group and the common species *pergandei* and *rostrata*. I have discussed nesting habits under the species in such detail as was warranted by the information available in each case.

The nests are small, usually comprising only 100 or even fewer individuals, but maximum numbers of workers in larger nests are probably greater than has been reported. I consider it probable, on the basis of a few of my own observations, that nests containing 300 or more workers are not uncommon in the ecologically most suitable areas. Nests containing more than 30 workers generally contain more than one dealate female, although there are no observations recorded suggesting the means by which this pleometrotic condition originates. The finding of many solitary dealate females during the winter and spring in temperate latitudes suggests that the method of nest founding is the usual one among ants, while the readiness of the queen to forage even after the nest is well established perhaps shows that she hunts actively during the incipient period of the nest while she is alone. Another possibility is that the seemingly unnecessarily large size of the nest chamber has something to do with bringing Collembola within range of the queen and also of the workers in established nests.

In the United States, the winged forms usually appear in the nest during August. This has been confirmed by many dated specimens sent me from all over the eastern United States. In a few cases, specimens have been taken on the wing before the middle of August (see M. R. Smith, 1931, p. 699) in Illinois, so that winged adults may occasionally be present in the nest at the end of July. Records of winged phases in the nest cover species of both subgenera, include all of the common species but *ornata* and *dietrichi*. The winged forms of these two species remain unknown. Correlated with this information is the record concerning the captures of solitary females. Through the very full data sent by my correspondents, I have been able to trace nearly all of our species through the autumn, winter and early spring as solitary female records. I think the evidence is sufficiently strong that I may hazard the generalization that all of our *Smithistruma* species produce winged forms late in the summer, the nuptial flight (which has not been observed) taking place in August, or in the South possibly during September. The females then spend the winter in solitary seclusion, perhaps feeding on collembolans active during the warmer winter days. The first workers do not hatch until

late in the succeeding spring. The females of *S. margaritae* may follow this schedule in the Gulf States, for Mr. Wilson has taken solitary females in Alabama during October and November. With regard to this species, we need to know whether or not winged forms are produced earlier in the summer.

The regularity with which most of our North American *Smithistruma* follow this cycle of production of sexual forms and nest-founding suggests, in contrast to the more irregular *Strumigenys louisianae*, that the species of the true Nearctic groups have been acclimatized for a long time in temperate regions. It may be suggested, in view of the close relationships with the East Asian fauna, that the Nearctic fauna arrived by way of the Bering Land Bridge, reaching the North American Continent during milder preglacial times. A few of the species do not occur in the extreme southeastern United States at all except at fair heights in the Appalachians, and others seem to be rarer and more depauperate in the Gulf States, especially in Florida, than they are in the states between the Great Lakes and northern Mississippi and Alabama. I think this evidence runs counter to the opinion of Wheeler, expressed on several occasions, that the Nearctic dacetines as a group have migrated northward from the Neotropical Region.

Identification of *Smithistruma* specimens is a rather tricky business, requiring a certain amount of experience even when suitable keys and illustrations are available. The insects are quite often covered with a whitish granular substance, apparently a secretion of some sort and occurring in living specimens, that may obscure certain details and thereby change the habitus quite radically. Depilated specimens are another source of confusion, and determinations based on single strays in which most of the hairs are missing must always be considered doubtful.

#### Subgenus WESSONISTRUMA Brown

*Smithistruma* (*Wessonistruma*) Brown, 1948, Trans. Amer. Ent. Soc. 74:106. *Strumigenys* Emery, 1895, Zool. Jahrb. Syst. 3:326, part. (not Fred. Smith 1860). *Strumigenys* (*Cephaloxys*) Emery, 1922, Gen. Ins. Fasc. 174:325, part. M. R. Smith, 1931, Ann. Ent. Soc. Amer. 24:688, part. *Strumigenys* (*Trichoscapa*) M. R. Smith, 1943, Amer. Midl. Nat. 25:307, part. 1947, Ibid. 37:585-587, part.

Includes two aberrant Nearctic species, *pergandei* and *angulata*, easily distinguished by the short, broad clypeus and the elongate, sublinear mandibles, the latter subequal to the clypeus in length, with greatly exaggerated distemata so that the apical series of teeth occupy only a relatively small portion of the inner mandibular margin near the apex. Basal lamella stout, acute, dentiform, situated anterior to the clypeal border, visible in entirety at full mandibular closure. Head in general rather broad, with rounded and distinctly laterally expanded occipital lobes and parallel or subparallel preocular laminae. Pilosity of head and alitrunk consisting largely of short but broadly expanded spoon-shaped and spatulate hairs. Other characters as in Nearctic *Smithistruma sensu stricto*. The female has the characters of the worker.

The male of only one species (*pergandei*) is known; this differs but little from other Nearctic *Smithistruma* males, and is best described under the species heading below.

Of the two species, *pergandei* is a common species inhabiting the tier of states along the southern shores of the Great Lakes and other cooler regions



in the eastern half of the United States, while *angulata* is a much rarer species occurring in the Mississippi Valley and Gulf States.

*Wessonistruma* is clearly related to the other *Smithistruma* species of the North American fauna. There are also many morphological similarities to a female of an undescribed genus and species sent for comparison by Dr. K. Okano from Japan; Dr. Okano's genus is in turn very closely related to the European *Epitritus* Emery. It is very difficult to tell whether the similarities between *Epitritus* and *Wessonistruma* are due to convergence or to near ancestry. I believe that the examination of the *Epitritus* male and that of the new Japanese genus, when found and certainly associated with the opposite sex, will help greatly in solving this phylogenetic problem.

The biology of *S. (W.) pergandei* is rather well known, for it was upon this species that L. G. Wesson made the first observation of the specialized predation on collembolans now known to be characteristic of widely separated higher dacetine groups. While *pergandei* is rather flexible in its nesting habits, it is quite often found in the nests of ants of other tribes. Too few records of *angulata* are known to permit of the present safe statement of ethological generalizations concerning it.

SMITHISTRUMA (WESSONISTRUMA) PERGANDEI (Emery)

Text-fig. 5, Pl. 3, fig. 29

*Strumigenys pergandei* Emery, Zool. Jahrb. Syst. 8:326-327, Pl. 8, figs. 17, 18, worker, female, male. *Strumigenys pergandei* Forel, 1901, Ann. Ent. Soc. Belg. 45:339. Wheeler, 1908, Bull. Amer. Mus. Nat. Hist. 24:148, worker, in key. 1910, Ants. Columbia Univ. Press, N. Y., pp. 24-25, fig. 11D, female wing. Kennedy and Schramm, 1933, Ant. Ent. Soc. Amer. 26:95-97, 100, biology. L. Wesson, 1936, Ent. News 47:171-174, biology. *Strumigenys (Cephaloxys) pergandei* Emery, 1922, Gen. Ins. Fasc. 174:325. M. R. Smith, 1931, Ann. Ent. Soc. Amer. 24:698-699, Pl. I, fig. 4, worker. L. and R. Wesson, 1939, Psyche 46:91-92, biology, p. 110, in key. Buren, 1944, Iowa State Col. Jour. Sci. 18:290, Iowa records. *Strumigenys (Trichoscapa) pergandei* M. R. Smith, 1943, Amer. Midl. Nat. 30:307. 1947, Ibid. 37:587. *Smithistruma (Wessonistruma) pergandei* Brown, 1948, Trans. Amer. Ent. Soc. 74:106.

*Worker*: TL 2.59-2.88, HL 0.63-0.68, WL 0.62-0.72, CI 70-74, MI 28-31. Previously well described and figured; readily recognized by most specialists who have to deal with the species. Clypeus with a nearly flat surface, averaging 1.4 times as broad as long, its free border broadly and evenly rounded except for the anterior portion, which is transverse and nearly straight. Mandibles averaging about 9/10 the length of the clypeus, slender and very gradually tapered toward the apices, slightly curved, converging gently and meeting only along the short apical (masticatory) borders. Basal mandibular tooth sturdy, strongly acute, situated a short distance anterior to the clypeal border and fully exposed at normal closure. Diastema very large, occupying approximately as much of the length of the inner mandibular border as the apical series of teeth, the latter consisting of three or four short acute teeth alternating with teeth modified into low, rounded lamelliform lobes; both teeth and lobes becoming gradually shorter toward the apex. The apex curved gently ventrad, bearing the usual four minute preapical denticles and a stout apical tooth. Antennal scapes strongly bent near their bases, somewhat incrassate and depressed. Apical segment of funiculus about as long as the first four funicular segments taken together. Labral lobes ("maxillary lobes" of Wesson) prominent, slender, at least half as long as the mandibles when in the extended position.

Alitrunk seen from above with a broad, laterally convex pronotum, the latter feebly submarginate dorsolaterally and weakly longitudinally carinate medially. Mesonotum separated from the pronotum by a usually moderately distinct, rather narrow semicircular sulcus; mesonotal disc anteriorly only slightly more than half as wide as the pronotum, posteriorly narrowed, the sides forming shallow even concavities with the sides of the propodeum; propodeum widening slightly posteriorly. Seen in profile, anterior part of



mesonotum forming a low, obtuse peak, leading up to which the pronotal outline is very weakly convex; the remainder of the mesonotum together with the propodeal dorsum forming a very feeble concavity. Petiolar peduncle very slender, tapered anteriorly, node a bit more than one half the width of the postpetiolar node; convex dorsally, as in the postpetiolar node; somewhat shining in most specimens, at least over the posterior half or more of the nodal surface. Propodeal teeth lamelliform and rather small, with fairly broad infradental lamellae becoming broader and convex ventrally.

Head hairs mostly broadly and suborbically spoon-shaped or spatulate, the broadened portions lying close to and parallel with the integumental surface, each with a short, inconspicuous peduncle. Free clypeal margin and anterior border of scape with slightly longer spatulate hairs projecting anteriorly as a fringe; these short in the center of the free clypeal border and at both ends of the scape. The squamose hairs become sparser on the upper dorsum of the head, but are still fairly abundant and are a little larger than those densely crowded on the clypeal disc. Alitrunk dorsally with more sparsely arranged spoon-shaped hairs bending toward the midline. Both nodes with small, distinctly spatulate appressed and reclinate hairs sparsely arranged on their dorsal surfaces and a few longer, fine hairs on their lateral surfaces, all directed posteriorly. Dorsum of gaster with a few fairly long fine erect hairs, several of which may be weakly broadened or truncate at their apices.

Color usually medium ferruginous throughout.

*Female:* Compound eye long-oval, greatest diameter about 0.12 mm. Except for the usual differences of full sexuality, very much like the worker. Mesonotum with punctulae arranged in longitudinal lines forming a kind of fine striation. Mesonotal pilosity like that of head, but a little less abundant. Described from Virginia, Pennsylvania and Ohio specimens.

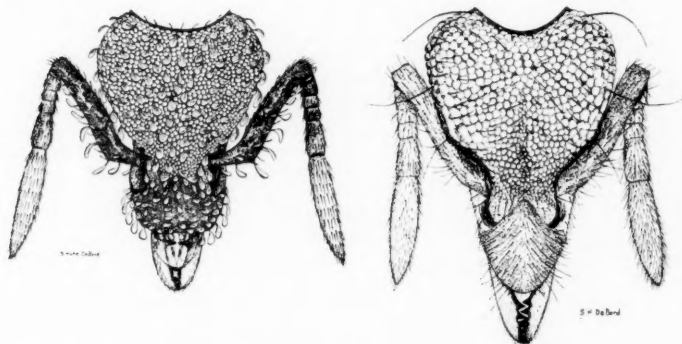
*Male:* TL 2.62-2.80, HL 0.55-0.57, CI 72-74. Full length of average mandible, measured along external border, 0.17-0.19 mm., greatest diameter of eye 0.18-0.20 mm., always slightly greater than the length of a mandible; eye distant from mandibular insertion by about half its greatest diameter. Mandibles edentate, acute apically, the two apices meeting at closure; apical and basal borders distinct, separated by a low curve or rounded angle. Notauli and parapsidal furrows feebly marked, the later becoming obsolete posteromedially; sculpture of scutum and scutellum as in female. Nodes moderate in size, shining above; ventral spongiform tissue distinct and reticulated, but small and narrow compared to those of worker. Propodeal teeth represented by low, blunt subrectangular processes; infradental lamellae reduced to carinae which are feebly broadened and reticulate ventrally. Gaster broad, smooth and shining throughout.

Color sordid medium ferruginous; head entirely or in part much darker; legs, mandibles, antennae and genitalia ivory yellow. Forewing length 2.40-2.45 mm.; venation as in Wheeler's figure (loc. cit.), more nearly complete than in *pulchella*. Volsella larger than that of *pulchella*, *talpa*, etc.; similar in size and form to that of *rostrata*, the digitus not noticeably constricted and rather acute at apex. Described from four males from Ohio and Virginia. See original figures of Emery.

Type material representing all three castes presumably in Emery Coll. and in other European collections. *Type locality:* Washington, D. C. (T. Pergande), restricted by Smith, 1931. Other original localities cited by Emery are Maryland (T. Pergande) and Beatty, Pennsylvania (P. J. Schmitt). Specimens from all three localities in various North American collections marked "type" are probably only nidotypes; there is no certainty that Emery has examined any of these specimens.

I have examined material from all of these original collections, plus about 65 nest series and numerous strays. I shall forego the listing of these localities in their entirety, but the unusual range of the species, now considered to be nearly completely known, is outlined by the citation of a few of the collections seen plus some Iowan records by Buren considered as completely trustworthy without a check on the specimens. *Pergandei* occurs in a broad belt extending from eastern Massachusetts and northern Virginia west through Pennsylvania, Maryland and southern New York, blanketing Ohio and extending to islands in Lake Erie, even to those along the northern shore of the lake. It probably occurs in much of Indiana, and is known from northern and central Illinois from collections by the Illinois Natural History Survey and by Dr. Orlando Park. Records from deep in Iowa include Boone, Holy Cross and Bellevue (W. Buren, loc. cit.). In the Appalachians, the species is found at least as far south as northeastern Tennessee, where

it has been taken in the Holston Mts., Sullivan Co. (J. W. Jones). In central Pennsylvania (Centre Co.), in an Appalachian Valley at 1200 feet altitude, it is rare (W. L. Brown), but farther south it occurs at 2500 feet at Draper Mt., Pulaski Co., Virginia (B. D. Valentine). Well over 100 colonies seem to have been taken in Ohio by the Wessons and by Dr. C. H. Kennedy and students, and this state appears to be at the center of the range and is also perhaps the most favorable area ecologically for the development of the species. The heavily and very systematically collected state of Illinois shows relatively few records by comparison, and even these records are from the central and northern sections. I have often doubted Forel's record of the species from Boston, since three seasons of sporadic search in likely areas around the city have failed to yield a single specimen. I was therefore greatly surprised to receive specimens from a Berlese funnel sample taken from leaves and trash accumulated at the base of the steps in front of the Biological Laboratories at Harvard University, steps over which I have passed continually for three years. These specimens were taken by Mr. Kenneth Christiansen, a fellow student, who was collecting springtails from the litter gathered along the bases of the steps. I returned with Mr. Christiansen to the same spot the following day and found a number of additional workers, but the nest itself could not be located. This record, Cambridge, Massachusetts, appears to be the northernmost locality from which the species has been recorded.



Text figs. 5, 6.—5. (left) *Smithistruma* (*Wessonistruma*) *pergandei* (Emery), worker, head in full-face view (after M. R. Smith); 6. (right) *Smithistruma* (s. str.) *laevinasis* (M. R. Smith), worker, head in full-face view (after M. R. Smith).

The biology of this species has been described by the Wessons in considerable detail; in his paper of 1936, Dr. L. G. Wesson was the first to record the collembolan predation of this ant, a habit which is apparently shared by many other dacetines of the higher genera. Nesting habits have been outlined by the Wessons and by Kennedy and Schramm, and the abundant ecological notes furnished with specimens by various correspondents show that the observations published by the earlier authors will serve to describe the nest sites in all parts of the range. *Pergandei* is very flexible in this respect, and it will nest in rotten logs, in the soil, or under stones in the soil. It is very often found in the nests of larger ants, where it probably preys on *Cyphodeirus* and other myrmecophilous collembolans. I have taken 224 workers and 3 queens from a rotten log in a city park in Philadelphia, and so many workers escaped that I consider this nest to have had a population of close to 300 adults.

While L. G. Wesson thought that *pergandei* showed no prey preference among the families of the Collembola, observations made by Mr. E. O. Wilson (in litt.) and myself indicate that there may exist rather strong selectivity with regard to prey among other species of *Smithistruma*. A vial with a series of *pergandei* from Draper Mt., Virginia (B. D. Valentine) mentioned above, contained mangled specimens of *Entomobrya pur-*

*purascens* Packard (2); *Pseudosinella petterseni* Börner (3); *Hypogastrura macgillivrayi* (1). The last-named specimen was in relatively good condition, and may or may not have been a part of the prey of the ants. Determinations of Collembola were made by Mr. Kenneth Christiansen.

*S. pergandei* could scarcely be confused with any species but *angulata*, and distinguishing characters are listed under that species, described below.

SMITHISTRUMA (WESSONISTRUMA) ANGULATA (M. R. Smith)

*Strumigenys* (*Cephaloxys*) *angulata* M. R. Smith, 1931, Ann. Ent. Soc. Amer. 24:697-698, Pl. 1, fig. 3, worker. *Strumigenys* (*Cephaloxys*) *angulata* L. and R. Wesson, 1939, Psyche 46:110, worker, in key. *Strumigenys* (*Trichoscapa*) *angulata* M. R. Smith, 1947, Amer. Midl. Nat. 37:587. *Smithistruma* (*Wessonistruma*) *angulata* Brown, 1948, Trans. Amer. Ent. Soc. 74:106.

*Worker*: TL 2.24-2.41, HL 0.55-0.58, WL 0.55-0.61, CI 73-76, MI 31-33. Measurements taken from two cotypes, one of which has been designated as *lectotype* (see below), plus nine additional workers taken from a single nest in Alabama. Smith's original figure and his original description characterize this ant very well, and I need add only a few morphological details and some other data here.

Mandibles slender, about as long as the clypeus; seen from the side, their apices are slightly thickened and the extreme tips ventrally deflected. The shafts are gently curved inward, and the extreme apices meet along the short series of apical teeth. The basal tooth is a little smaller than in *pergandei*, but is placed similarly. Diastema very large, distinctly longer than the space occupied by the apical series of teeth. These teeth are all acute, and do not alternate with rounded lobes as in *pergandei*. The first tooth of the series is distinctly shorter than nos. 2 and 3.

The very angulate shape of the clypeus and the antennal scapes can be seen readily in Smith's figure (loc. cit.), although the antennae in the figure are a bit overinflated.

Pronotum with anteriorly rounded border, without humeral angles, but with dorso-lateral carinuliform margins and a distinct median carinula continuing posteriorly to metanotal groove; the latter groove fairly distinct, but only weakly depressed. Propodeal dorsum with lateral carinuliform margins, seen in profile feebly convex. Propodeal teeth moderate in size, acute; infradental lamellae deeply excised above, with a small rounded expansion below.

Petiole with a small node, not broader than long seen from dorsal view; the angle between the anterior face of the node and the peduncular dorsum partly filled in by a low cariniform edge which runs down the center of the face. Postpetiolar disc moderate in size, about twice as wide as the petiolar node, convex, smooth and shining above as in other North American *Smithistruma*. Gaster with slightly depressed dorsum; basal costulae 15-18 in number, rather coarse and extending 1/3 the length of the basal gastric tergite or slightly more.

Punctulation of the pronotum often rather low and feeble, with a faint suggestion of longitudinal striation or rugulation of the most indefinite sort; some areas may appear nearly smooth and weakly shining. Sides of alitrunk very largely smooth and shining. The pilosity of the head is similar to that of *pergandei*, but the individual hairs are relatively smaller, with the exception that the hairs fringing the free clypeal border are relatively much larger than those of *pergandei*, with a more elongate-spatulate shape. Pilosity of alitrunk consisting of a very few small subreclinate spoon-shaped hairs. Humeral pair scarcely enlarged or differentiated from other alitrunk hairs, but reflexed posteriorly. Mesonotum with a single moderately long, fine erect hair on each side anteriorly and one or two pairs of small erect spatulate hairs posteriorly. Nodes and gastric dorsum with a sparse growth of long, fine, tapered erect hairs. Neither of the two nodes with reclinate or other spatulate hairs.

Color light to medium ferrugineous.

*Gynotype female*, dealate: TL 2.72, HL 0.64, CI 75, MI 32. Differing from the worker in the usual ways; color little if any darker. Deposited in INHS. Taken singly from the soil cover at Herod, Illinois on May 17, 1944 (H. H. Ross and M. W. Sanderson).

Male unknown. Material examined consisted of the gynotype just described, from Illinois; two worker cotypes [MCZ]. Other cotypes are in the USNM, but I have not examined these. *Type locality*: Louisville, Mississippi, nest in a crevice in a rotten log in

a dense woodland thicket (M. R. Smith). A fair-sized series has also been studied from a collection made in Moody Swamp, Tuscaloosa Co., Alabama (B. D. Valentine). I add excerpts from Mr. Valentine's letter concerning this series:

"The first collection in Moody Swamp, made on May 9, 1949, is from a colony of *Strumigenys* [*louisianae* Roger] nesting in a very rotten and mushy pine stump. The *Strumigenys* were under the bark and also in the wood to a depth of about two inches. The single *Smithistruma* [*angulata*] queen was with the *louisianae*, as were some mutilated Collembola. Three days later, I returned to the same spot, hoping to find some more *Smithistruma*. A few yards away was a small colony of [*angulata*] under the bark of another wet and rotten pine stump. These were at ground level, while the May 9 collection was made an inch or two below the top of the stump (which was about 20 inches tall)."

By a curious coincidence it happens that before I became acquainted with Mr. Valentine, I found that of three specimens labelled as cotypes in the Museum of Comparative Zoology, all from Louisville, Mississippi, one individual was actually a specimen of *Strumigenys louisianae*. Whether this specimen was mixed in with the *angulata* types before or after collection cannot now be determined, and I have removed it from the series to prevent later confusion. The possibility, suggested by the bits of information presented, that *angulata* may sometimes start its colonies as an inquiline in nests of other dacetines should not be overlooked by future investigators. Different dacetine species are so often found nesting very close together, however, that repeated detailed observations will be required before any such relationship between two species can be considered confirmed.

The two new localities are the first reported since the type collection, and through them, the range of this rare species is very greatly extended. It probably occurs sporadically throughout much of the Mississippi Valley and the Gulf States. Distinction from *fergandei* may be made by means of the different mandibular dentition, the angular clypeus, and the differences in general size and pilosity.

#### Subgenus SMITHISTRUMA s. str.

##### CLYPEATA GROUP

This group comprises five North American forms: *clypeata*, *rohweri*, *pilinanasis*, *laevinasis* and *brevisetosa*, distinguishable from other North American groups chiefly by the form of the head and clypeus, which superficially resembles that of the much larger *Weberistruma* forms. The typical cuneiform head shape is shown in fig. 6, reprinted here from M. R. Smith's 1931 paper (which should be consulted for other figures of species of the group). Smith's figures show the antennae too thick, the mandibular details are incorrect, and the pilosity in the *pilinanasis* drawing is too fine, especially that of the clypeus, but in spite of these minor errors, the habitus is well shown. The cuneiform outline of the head is achieved by the combination of only relatively slight lateral expansion of the lateral occipital lobes with the straight, convergent preocular laminae, the latter being so placed as to fill in the outline of a straight-sided wedge with the closed mandibles at the apex.

The size range is actually higher than has been reported in the past, most specimens falling between TL 2.00 and 2.50, HL 0.58 and 0.63, with relatively slight differences between species. The head is narrow, CI varying only slightly from *rohweri* (63-66) to *laevinasis* and *pilinanasis* (66-69). These differences will probably be lessened when more specimens are available for measurement. The clypeus is usually approximately as broad as long, its surface more or less convex, especially near the borders, the free border broadly to fairly narrowly rounded and showing a more or less distinct tendency

toward bimargination, although the pilosity is usually so dense that the border is rather indistinct. Clypeus usually shining.

The mandibles are convex above and rather uniform in size, shape and dentition. The dorsal surface is slightly more convex than is usual in other North American *Smithistruma*, and the blade is rather robust in general, the MI ranging from 17 to 21 except in *rohweri* (13-15). The dentition, so far as has been determined, is much as in Emery's figure of *clypeata* (Emery, 1895, fig. 22). The figure given here (fig. 16) agrees in detail, even to the slight curvature of the apex of the basal tooth, and the only important divergence from Emery's figure lies in the small tooth, indicated by a dashed line, which sometimes occurs in the apical end of the diastema. Although *rohweri* and *brevisetosa* have been examined in such small series that I have not been able to confirm the exact details of their dentition. I do not doubt from what I can see that the number and positions of the teeth and basal lamella are much the same as in *clypeata*, *laevinasis* and *pilinasis*. The basal tooth is long, slender at the apex, and usually feebly deflected basad, longer than the diastema following it, the latter invisible or indistinct at full closure.

The antennae only weakly curved basally, moderately incrassate, not otherwise remarkable. The remainder of the body not very different from those of most other North American groups in general structure, rather similar among the species. Pronotum in profile moderately convex, sloping gently up to the slight, rounded-obtuse hump at the fusion point with the mesonotum. Seen from above, promesonotum oval in outline, not laterally marginate and without definite humeral angles; humeral tubercles at most weakly developed. Posterior mesonotum feebly narrowed, its dorsum weakly concave, but with a median longitudinal carinula filling out the lateral-view profile to a straight horizontal outline. Metanotal groove poorly developed and indistinct. Propodeal teeth short, acute, lamellate, continued ventrally by narrow, evenly concave infradental lamellae.

Petiole with a slender, tapered peduncle and a small, rounded node, punctulate and opaque. Postpetiolar disc transverse ellipsoid, convex, smooth and shining. Both segments with well developed and voluminous spongiform appendages. Gaster and general body sculpture of the type common to most Nearctic *Smithistruma*. Pilosity of clypeus varying with the species from finely filiform to broadly squamose and appressed. The pilosity of the rest of the body usually varies in thickness proportional to that of the clypeus. The hairs (ground pilosity) of the upper dorsum of the head are mostly long, weak and reclinate to subreclinate-arched, directed mesad. These hairs vary from finely filiform in *laevinasis* to somewhat strap-like in *rohweri*, and the pilosity of the alitrunk, while much scarcer than on the head, is more or less similar in type. Dorsal surfaces of nodes and gaster with a few long, weak, more or less erect and crooked flagelliform or hypha-like hairs. Color varying shades of ferrugineous.

The female is similar to the worker, differing from the common caste in much the same ways as do those of other species of the genus. Males are known so far only for *clypeata* (refer to that species, described below), and it is expected that those of the other four species will show few significant differences from this general type when finally discovered.

The species are relatively uncommonly collected compared to forms like *talpa*, *pergandei*, *ornata*, etc., only *clypeata* being reasonably abundantly represented in collections. For this reason, little definite knowledge may be claimed regarding their biology, although several of the species have been found either in soil nests or in rotten logs. Several of the forms feed on *Collem-bola*, and I have little doubt that the diets of all are similar in this respect.

The species are told one from another mainly by pilosity characters, although other distinguishing features are not lacking. Because of the scarcity of material, the distinctness of one or two of the species cannot be convincingly demonstrated at this time. *S. brevisetosa* is the shakiest of the forms I here retain as separate species, and it seems probable that it will be synonymized with *pilinasis* before too long. *S. medialis* is synonymized here under *pilinasis* with little doubt. *Pilinasis* is the most variable species in the group, and variants near it must be carefully scrutinized and compared so that the full extent of its variation will become known. Some workers have expressed to me their belief that *pilinasis* and *laevinasis* are geographical variants (subspecies) of the same species. None of these workers has examined as much material as is available to me at present, and none can reconcile the very broad distributional overlap of the two forms without production of true intergrades. "Intergrades" from east central Illinois are certainly puzzling, but I think that they must be assigned to *pilinasis* on the basis of the enlarged hairs of the middle of the clypeus. More material may show that this Illinoisian form should be described as a distinct species. Another alternative, which must be based on far more material than now exists in collections, would be the synonymy of *laevinasis*, *pilinasis* and the Illinois form under one all-inclusive and very variable species, *pilinasis*.

The group is distributed throughout the milder parts of the United States east of the Great Plains, mostly in forested regions. The northern limits seem to rest in the states stretching from Illinois to New York, and in these states, the distribution is restricted mainly to lower altitudes and river basins. A worker collected by A. C. Cole from the Oregon-California border was determined by Smith (in litt.) as belonging to the *clypeata* group, but the specimen has been misplaced.

Other authors have associated various species, such as *bimarginata*, *talpa*, and *ohioensis* with the *clypeata* group, but of these only *bimarginata* could easily be associated with *clypeata*. I believe that *bimarginata* is sufficiently different to warrant its placement in a different group. The *talpa* group differs from *clypeata* in having a distinct mandibular diastema, and the number of principal teeth in the apical series is reduced to 4. It (*talpa*) also differs in other characters which relate it more closely to *pulchella* than to *clypeata*. *Ohioensis* differs rather radically in the shape of the mandibles and in dentition.

SMITHISTRUMA (SMITHISTRUMA) ROHWERI (M. R. Smith)

*Strumigenys* (*Cephaloxys*) *rohweri* M. R. Smith, 1935, Ann. Ent. Soc. Amer. 28:214-215, worker. *Strumigenys* (*Cephaloxys*) *rohweri* L. and R. Wesson, 1939, Psyche 46:109, in key. *Strumigenys* (*Trichoscapa*) *rohweri* M. R. Smith, 1947, Amer. Midl. Nat. 37:387.

Worker (3 specimens, including 1 nidotype): TL 2.26-2.35, HL 0.60-0.62, WL

0.57-0.60, CI 63-66, MI 13-15. A species related to *clypeata*, differing by the following distinctive qualitative characters:

(1) Clypeal surface covered rather densely with broad, appressed white scale-like hairs, oval or suborbicular in shape and larger on the posterior part of the disc, smaller and more crowded toward the free clypeal border. Individual hairs near the center of disc larger, broader and more distinct than those of *clypeata*, so densely arranged that little of the distinctly shining clypeal surface is ordinarily visible. On the center of the free anterior border, the smaller scales are massed in such a way that the center of the margin appears to have a small blunt peak; under liquid, however, the margin is seen to be very broadly rounded, or at least with no trace of even the most obtuse peak. The hairs of the free border are not projecting as in *clypeata*, but instead are appressed in much the same fashion as are those on the center of the disc.

(2) Ground pilosity of cephalic dorsum above clypeus with broader, more spatulate or strap-like apical portions, whitish and conspicuous.

(3) When head is viewed from above, eyes not or scarcely protruding visibly at the sides.

(4) My (few) specimens lack long outstanding flagellate hairs on the head. Humeral flagellate hairs very weak, sometimes missing in roughly handled specimens. Middorsal region of alitrunk with a pair of relatively short flagellate hairs.

(5) Basal gastric costulae less distinct than are those of *clypeata*, the spaces between them feebly and superficially reticulate-striate. Color medium ferrugineous.

Male and female unknown to me. Lectotype and other copies in USNM.

Type locality: Holly Springs, Mississippi (L. C. Murphree). One specimen seen from type nest (nidotype).

Two additional workers, from Aberdeen, Mississippi (H. T. Vanderford) were also examined. The colony from the type locality was said by Smith to number 75 to 100 workers and a number of dealate queens. It is regrettable that the queen remains undescribed under these circumstances, particularly as it is so desirable to have the sexual forms described from the type nest in order to avoid later confusion. One of these females should be fixed as gynotype, if possible without further delay.

The worker of *rohweri* is very distinctive in appearance, and of all the true *Smithistruma*, it approaches *Weberistruma* most closely. I do not know how much this resemblance is due to convergence and how much to true relationship.

#### SMITHISTRUMA (SMITHISTRUMA) CLYPEATA (Roger)

Pl. II, fig. 16

*Strumigenys clypeata* Roger, 1863, Berlin. Ent. Zeitschr. 7:213, worker. *Strumigenys clypeata* Mayr, 1887, Verh. Zool.-bot. Ges. Wien 37:371, worker; Emery, 1890, Bull. Soc. Ent. Ital. 22:Pl. 8, fig. 3, worker; 1895, Zool. Jahrb. Syst. 8:328, Pl. 8, figs. 21, 22, worker, female, male; Wheeler, 1908, Bull. Amer. Mus. Nat. Hist. 24:148, in key. *Strumigenys (Cephaloxys) clypeata* Emery, 1922, Gen. Ins. Fasc. 174:325; M. R. Smith, 1931, Ann. Ent. Soc. Amer. 24:699-700, Pl. 3, fig. 9, worker; L. and R. Wesson, 1939, Psyche 46:93-94 (biology), 109, in key. *Strumigenys (Trichoscapa) clypeata* M. R. Smith, 1947, Amer. Midl. Nat. 37:587.

Worker: TL 2.16-2.52, HL 0.58-0.62, WL 0.58-0.65, CI 65-67, MI 17-20. Measurements made on 30 workers, including the size extremes from a much larger series from the localities listed; type not seen.

This species has been described fairly well and figured several times in the literature. It is the most common species in its group, among which it may be distinguished by the following characters:

(1) Clypeus very broadly rounded, under liquid the anterior border straight and transverse or nearly so in the center. Surface of disc weakly convex, sometimes with a very feeble impression behind the middle. Surface nearly smooth, definitely shining when clean, covered with a dense, subappressed oval-spatulate pilosity. Hairs fringing free border 13-16 on each side of the center, linear-spatulate, 2-4 times as long as those on the disc and projecting anteriorly from the border with slight curvature toward the middle. Clypeal hairs in Smith's figure (1931, Pl. 3, fig. 9) too small.

(2) Eyes usually if not always slightly but distinctly projecting at the sides of the head, dorsal view.

(3) Pilosity of upper dorsum of head mostly filiform, those nearest the clypeus



slightly flattened, but never so much as in *rohweri*. Long weak flagellate hairs, bilaterally paired, 2 or 3 pairs on the lateral borders of the occipital lobes, the posteriormost pair not arising so far to the sides; humeral pair and up to 3 or 4 other pairs on the alitrunk dorsum; nodes with a few (shorter) and gaster with a sparse growth of very long ones.

(4) Gastric costulae 22-28, distinct, occupying about  $\frac{1}{4}$  the basal tergite. Color medium to dark ferruginous, head often a bit darker than rest.

*Female*: TL 2.63-2.72, HL 0.63-0.64, CI 68-69, MI 17-18, from 3 females, Illinois and Florida.

*Male*: TL 2.56-2.62, HL 0.51-0.52, WL 0.80-0.81, greatest diameter of eye 0.20, CI 75, full length of mandible 0.15.

Eyes very convex, placed far forward, distant by about  $\frac{1}{10}$  their greatest diameters from the mandibular insertions. Mandibles slender and acute, tips meeting at full closure; apical border concave, edentate, apicobasal angle replaced by a gentle convexity. Notauli and parapsidal furrows present but weak. Mesonotum not longitudinally rugulose or striate, but with a faint median longitudinal furrow. Propodeal teeth low, obtusely subangulate, continued ventrally as low carinae. Body hairs fine, longer and more abundant than in *talpa* or *pulchella* males; two long flagellate hairs on each side of the head behind the eyes. Petiolar node a little larger than in *talpa* or *pulchella*; spongiform appendages represented by very fine white, reticulate cariniform vestiges. Surfaces of nodes fairly strongly shining, with feeble vestiges of the sculpture visible under proper light. Coloration as in *talpa*.

Forewing L ca. 2.25. Venation even more reduced than in *pulchella*, only R + Sc, stigma and 2r defined, and these with only feeble straw-colored pigmentation. Volsella similar to that of *talpa*, but digitus more weakly constricted.

Roger's original worker types are in the collection bearing his name and also in several other European collections. The types of the male and female castes in Emery Coll. No other types were seen for the present work.

*Type locality*: Louisiana (Collection usually credited to Roger).

#### MATERIAL EXAMINED

ALABAMA: Holt, Tuscaloosa Co., under large stone on hillside (B. Valentine).

FLORIDA: Pasco Co. (P. J. Schmitt).

ILLINOIS: near Quincy (C. C. Hoff); dealate female, Havana, rotten log in woods, Nov. 9, 1943 (H. H. Ross and M. W. Sanderson).

NEW JERSEY: pine barrens in s. part of state (L. G. Wesson).

NORTH CAROLINA: Fayetteville; Raleigh; Berlese funnel (D. L. Wray).

OHIO: vicinity of Jackson (L. and R. Wesson).

PENNSYLVANIA: Beatty [near Latrobe] (P. J. Schmitt).

TENNESSEE: University Farms, Knoxville (D. W. Pfitzer).

This species ranges much as do several other species in the Nearctic fauna, its probable northern limits being in Long Island, southern Pennsylvania and west at least to central Illinois. From this region, it ranges south to Florida and Louisiana at least as far west as the Mississippi Delta. It is nowhere as common as species like *ornata* and *talpa* in the same range. Abundant records show that it will nest in the soil cover, beneath stones, or in rotten logs, usually in forested areas. It has not yet been directly reported as feeding on springtails, but almost certainly does so.

Damaged specimens, especially those with the clypeal and upper cephalic pilosity disturbed, are apt to be confused with *pilinasis*. The record from New Jersey, mentioned above, is such a case and is considered somewhat doubtfully determined.

#### SMITHISTRUMA (SMITHISTRUMA) BREVISSETOSA (M. R. Smith)

*Strumigenys* (*Cephaloxys*) *clypeata* var. *brevisetosa* M. R. Smith, 1935, Ann. Ent. Soc. Amer. 28:215-216, worker. *Strumigenys* (*Cephaloxys*) *brevisetosa* L. and R. Wesson, 1939, Psyche 46:108, worker, in key. *Strumigenys* (*Trichoscapa*) *clypeata* var. *brevisetosa* M. R. Smith, 1947, Amer. Midl. Nat. 37:587.

*Worker*: I have seen the type and several more recently collected specimens of this species which leads me to believe that it will eventually be synonymized with *pilinasis*. The total length given by Smith for the original specimen is 1.3 to 1.5 mm., but my own hasty measurement shows that HL is about 0.60, CI 67 and MI 20, while the TL

is not more than  $\pm 0.15$  from 2.00 mm. Other specimens referable to this species show measurements and proportions entirely within the range of variation of both *clypeata* and *pilinis*, with the HL in the majority of specimens at 0.60-0.61.

*Brevisetosa* is supposed to differ from *pilinis* in having shorter clypeal pilosity and a more evenly rounded anterior clypeal border; the clypeal surface is moderately to fairly strongly shining, and there seem to be fewer hairs in the total cephalic pilosity. In the type specimen, the hairs seem to me to be slightly less abundant than in most *pilinis* specimens I have seen, but this is a character subject to variation and also to change in aspect due to rubbing of the pilosity before or after collection.

The clypeal pilosity does not appear to be significantly shorter nor outside the normal range of variation so far as apical enlargement of the individual hairs is concerned when considered against a large series of *pilinis* specimens. *Pilinis* specimens from the District of Columbia, Pennsylvania and Ohio seem to have more opaque clypeal surfaces than do southern specimens referred here to *brevisetosa*, and the difference in wideness of the rounding of the free clypeal border, while elusive, may hold taxonomic significance. The very meagre and unsatisfactory material presently available for both forms is inconclusive, but each new collection seems to bring them closer together. Two alternatives are possible: *brevisetosa* is a separate species or, less probably, a southern race of *pilinis*, or else it is an absolute synonym of a species known to be very variable, bearing the name *pilinis*. I favor the latter view, but cannot presently prove it to be true. I therefore leave *brevisetosa* as a provisional species until the time when a reviser of the group with more material at hand can make a sounder decision. The definitely shining clypeus with its very broadly rounded border and the seemingly slightly sparser pilosity, are the only characters I can see at present to separate *brevisetosa* from its ally.

*Gynotype female*, dealate: I reluctantly, in view of the shakiness of this species, designate a specimen from the Bryce Lake, Alabama nest (see below) as gynotype. This specimen, to be placed in the MCZ by the collector, is very much like the females of *pilinis* I have seen, but differs in the same way as do the workers of the two species. The color is very dark; mesonotum approaching black and gaster deep castaneous.

#### MATERIAL EXAMINED

Holotype worker, a unique [USNM]. *Type locality*: Lucedale, Mississippi (H. Dietrich); taken while sifting for beetles.

Small series of workers and one female (gynotype), Bryce Lake, Tuscaloosa Co., Alabama (E. O. Wilson) "In cavity of a portion of a very rotten pine limb partly sunken in the earth and covered with leaf litter and tangled vines."

A single worker from a leaf mould Berlese funnel sample, Williamston, North Carolina (D. L. Wray); damaged, pilosity largely gone, det. *brevisetosa* by M. R. Smith, and this interpretation followed here, though this specimen is doubtfully named at best.

Mr. Wilson has observed *brevisetosa* in the laboratory. He has undoubtedly made some interesting observations on the feeding habits to be published in due course.

#### SMITHISTRUMA (SMITHISTRUMA) PILINIS (Forel)

*Strumigenys clypeata* var. *pilinis* Forel, Ann. Ent. Soc. Belg. 45:339, worker. *Strumigenys* (*Cephaloxys*) *clypeata* var. *pilinis* Emery, 1922, Gen. Ins. Fasc. 174:325; M. R. Smith, 1947, Amer. Midl. Nat. 37:587.

*genys* (*Cephaloxys*) *pilinis* L. and R. Wesson, 1939, Psyche 46:109, worker, in key. *Strumigenys* (*Cephaloxys*) *medialis* L. and R. Wesson, 1939, Psyche 46:94-95, Pl. 3, fig. 1, worker, female. (New syn.). *Strumigenys* (*Trichoscapa*) *medialis* M. R. Smith, 1947, Amer. Midl. Nat. 37:587. *Strumigenys* (*Trichoscapa*) *clypeata* var. *pilinis* M. R. Smith, 1947, Amer. Midl. Nat. 37:587.

*Worker*: Principal dimensions entirely within the range of variation of *S. clypeata*, except that one specimen showed a CI of 64. Differing from *clypeata* in having a very slightly more narrowly rounded free clypeal border in most specimens and in the narrower, longer pilosity. The clypeal hairs are short, apically enlarged and obliquely suberect on the center of the disc, while those fringing the free border are longer, slender and feebly enlarged or merely truncated apically. The hairs on the margin are usually curved ventrally and somewhat medially, but in specimens from two east-central Illinois localities (Urbana, Danville, see below) the hairs are curved feebly away from the midline as in *laevinis*. The clypeal surface is very feebly shining to almost completely

opaque, but the clypeal opacity depending to at least some extent on the freedom from grease, dirt or what seems in most dacetines to be a film of some hardened secretion. Specimens from southern Ohio (*medialis* cotypes) seem to have the most opaque clypeal surfaces, but in any case the difference is a very slight one of very doubtful significance in so variable a species as *pilinasis*. The Wessons originally described *medialis* on the basis of supposed differences in pilosity from *pilinasis*, but in this, they were misled by Smith's 1931 figure of the latter species (loc. cit.), which shows the clypeal hairs as very fine, including those of the center of the disc. The specimens from which this drawing was made (Washington, D. C., collected by Pergande; see below) have the clypeal pilosity definitely but slightly broadened apically. Forel says "not or slightly" enlarged in the original description, which was also from a specimen taken near Washington. Comparison was made between one of Pergande's specimens and the types of *medialis*, and Dr. L. G. Wesson seems perfectly satisfied that the only difference between these specimens that might be cited is the slight difference in degree of clypeal opacity. As I have stated above, I do not consider the difference sufficient to allow *medialis* to stand.

*Female*: TL 2.64-2.71, HL 0.62-0.65, WL 0.67-0.69, CI 67-69, MI 17-20. Described from 3 dealate females from Illinois (female from Herod designated here as *gynetype*; see below) Pennsylvania and Ohio.

Male unknown. Holotype in Forel Coll., gynetype in INHS. Types of *medialis* in MCZ, USNM and other American collections. Holotype of *pilinasis* not examined.

*Type locality*: Bank of Potomac near Washington, D. C. (A. Forel).

#### MATERIAL EXAMINED

DISTRICT OF COLUMBIA: College Hill, Georgetown, Washington (T. Pergande), a small series of workers, apparently from a single nest. [USNM, MCZ].

ILLINOIS: Herod, single dealate female from soil cover in woods, Feb. 2, 1934 (Frisson and Mohr), *gynetype*; Danville, 1 worker, base of rotten stump (J. Alsterlund) [INHS]; Urbana, 2 workers, March 25, 1911 (M. C. Tanquary) [MCZ]. Karber's Ridge (Sanderson and Stannard) [INHS, etc.].

OHIO: Beaver, Pike Co., Ohio, several workers and female from nest of about 30 workers and several dealate females in rotten log (L. and R. Wesson), types of *medialis*; also several workers seen from another nest taken in the vicinity of Jackson by the Wessons.

PENNSYLVANIA: Beatty (near Latrobe), a worker and a female (P. J. Schmitt, deposited in MCZ).

From the meagre records, *pilinasis* would seem to have a more northerly distribution than *brevisetosa*. This, of course, depends upon the very questionable distinctness of the latter species. *Pilinasis* will nest under stones, in the soil cover, or in logs. It feeds on springtails; details of biology are given by the Wessons with the *medialis* description, indicating that it is a very sluggish hunter.

#### SMITHISTRUMA (SMITHISTRUMA) LAEVINISIS (M. R. Smith)

Text-fig. 6

*Strumigenys* (*Cephaloxys*) *clypeata* var. *laevinasis* M. R. Smith, 1931, Ann. Ent. Soc. Amer. 24:701, Pl. 3, fig. 11, worker. *Strumigenys* (*Cephaloxys*) *clypeata* var. *laevinasis* L. and R. Wesson, 1939, Psyche 46:109, worker, in key. *Strumigenys* (*Trichoscapa*) *clypeata* var. *laevinasis* M. R. Smith, 1947, Amer. Midl. Nat. 37:587.

*Worker*: Dimensions as in *clypeata*, except that CI is slightly greater in average (66-68), and the mandibles are perhaps a trifle larger in average (MI 17-21). Measurements based on the type in the USNM and 14 other workers representing 5 colonies from Illinois and Tennessee.

In pilosity and narrowness of rounding of the free clypeal border, *laevinasis* represents the opposite extreme from *rohweri* and the next step beyond *pilinasis*. The clypeus is narrowly rounded anteriorly, with a usually more or less definitely shining, yellowish surface. The pilosity is very fine, filiform and tapered apically, the hairs in the center of the clypeus about as long as those along the border, and with the latter mostly curved weakly obliquely away from the midline. The hairs on the rest of the body are proportionately fine, and the paired and other flagelliform hairs in special positions are extraordinarily long, fine and crooked. Anterior border of postpetiolar disc with a row of fine, short longitudinal costulae.

*Gynetype female*: TL 2.73, HL 0.64, WL 0.70, CI 69, MI 18, forewing L. ca. 2.35. Anterior scutum perforated by a short and narrow but very deep, conspicuous pit, much stronger than the furrow found in the same position in some other dacetine species. This might be considered an abnormality, were it not that another female from the same nest has an exactly similar pit. The constancy of this character should be investigated in other nest series, since it appears to be very distinctive. Longitudinal rugulae distinct only in the middle of the scutum. Hairs on mesonotum and rest of dorsum of body long, fine and rather abundant. Ferrugineous; ocellar area infuscated. *Gynetype* [MCZ] described from an alate specimen, one of two sent me, University Farm, Knoxville, Tennessee, Aug. 14, 1947 (D. W. Pfitzer).

Male unknown. Types in USNM and Mississippi A. and M. College. These specimens were originally designated as cotypes; the specimen in the type drawer in the USNM is here designated as *lectotype*.

#### MATERIAL EXAMINED

*Type locality*: Louisville, Mississippi, from cavity in well-rotted log, densely wooded ravine (M. R. Smith); *lectotype* seen.

ILLINOIS: Valmeyer, forest debris (Smith and Stannard); near Collinsville, 1 female, ground cover, Feb. 9, 1944 (T. H. Frison); Siloam Springs, Brown Co. (C. C. Hoff). These localities in south and western part of the state along the Mississippi River.

TENNESSEE: Tellico River, Monroe Co., colony under bark of white pine log (J. W. Jones, Jr.); University Farm, Knoxville, large colony in small rotten log, with winged females (*gynetype* here) (D. W. Pfitzer).

VIRGINIA: M. R. Smith reports a collection from Hillsboro in the northern part of the state (J. C. Bridwell); I have not seen any specimens from this locality.

The records indicate a tendency to nest in rotten logs, but the records are still so few that no generalization may yet be safely made concerning nesting habits. The range of *laevinasis*, its clypeal pilosity, and the odd pit of the female scutum seem to indicate that the opinions expressed privately to me by several North American specialists that *laevinasis* is a subspecies of *pilinasis* are incorrect. More material will be needed to establish definitely its taxonomic position.

#### BIMARGINATA GROUP

With two species, *bimarginata* and *filiirrhina*, both very rare. Related to the *clypeata* group, but also with some similarities to the *ornata* group. Head narrow, cuneiform; clypeus rather small, with a rounded free border quite distinctly separated into dorsal (cultrate) and ventral margins. Surface of clypeus more or less concave or depressed, distinctly shining and sparsely tuberculate. Clypeal hairs relatively few in number, rather fine, with a distinct tendency toward curving away from the midline. Rest of body much as in *clypeata*, usually with long paired flagellate hairs present. Size and proportions of body much as in *clypeata* group, except that the mandibles are slightly longer. Basal tooth of mandible acute, visible in front of anterior clypeal border at full closure; diastema definitely larger and more distinct than in the *clypeata* group, at least as long as the length of the basal tooth, and fully visible at closure.

The two very rare species apparently live in the soil cover, but the biology cannot be certainly worked out until more records come to light. So far as is known, the group is restricted to the eastern half of the United States.

#### SMITHISTRUMA (SMITHISTRUMA) BIMARGINATA (L. and R. Wesson)

*Strumigenys* (*Cephaloxys*) *bimarginata* L. and R. Wesson, 1939, Psyche 46:95-97, Pl. 3, fig. 2, worker, female. *Strumigenys* (*Trichoscapa*) *bimarginata* M. R. Smith, 1947, Amer. Midl. Nat. 37:587.

*Worker*: TL 2.21-2.39, HL 0.60-0.61, CI 63-67, MI 18-22. (Description and measurements from the holotype and one additional worker from Illinois.) The two margins

of the free clypeal border are very distinct, the upper one concentric and slightly within the lower one as seen from dorsal view. The two margins are separated by a distinct round-bottomed groove traversing the entire free border from one lateral clypeal angle to the other. Clypeal hairs fewer than in *pilinosus* or *brevisetosus*, but more than in *ornatus*, the longest ones more than 1/3 the maximum width of the clypeus in length, outstanding, and curved weakly ventrally and more or less away from the midline, concentrated along the free border. These longer hairs are very fine, but have a slight, rather sudden apical enlargement, under very high magnification appearing weakly bifid or somewhat feebly fishtail-shaped. Hairs on the center of the clypeus very few, seemingly absent in one fair-sized area just posterior to the exact center, short, erect, not or almost imperceptibly enlarged at apices. Hairs on the upper dorsum of head densely arranged, abundant, quite uniform in size, form and orientation, long, erect, their apical halves curved strongly anteriorly and slightly mesad, their extreme apices weakly but suddenly broadened in much the same way as are the larger clypeal hairs.

The apical series of teeth on the mandible seems a bit more uniform than in the *clypeata* group as regards length of the individual teeth, but tooth no. 3 still appears slightly the longest. Alitrunkal hairs sparse and long, very slightly or not apically enlarged, also a few very long flagellate hairs here and on the nodes and gastric dorsum, the latter extremely long, mostly longer than the petiolar peduncle, curved posterodorsad.

A very distinct median curinula reaching from the anterior pronotal margin to the middle of the propodeal dorsum, and the posterior dorsum of the pronotum obscurely longitudinally rugulose or striate; ground sculpture of entire alitrunk dorsum moderately coarsely reticulate-punctate. Postpetiolar dorsum, gastric surface and sides of alitrunk largely smooth and shining; gaster with short basal costulae.

*Female* (description from gynetype; see below): TL 2.71, HL 0.62, WL 0.66, CI 61, MI 21. Dorsum of alitrunk with a rather dense growth of fine, whitish subdeclinate hairs and five or so pairs of long, weak, arching flagelliform hairs. Petiolar node with at angular summit in profile, its posterodorsal face with dense pilosity as described for the alitrunk. A few distinct longitudinal costulae, well spaced and parallel, on scutum and scutellum. Color, including vertex, medium ferruginous; gaster mahogany.

Male unknown. Worker (*holotype*) and female (*gynetype*) in MCZ; the designation of types has hitherto not been quite clear, but the description is that of the worker in the original reference so that this single specimen can be taken as the holotype. Gynetype is fixed by present designation of the original female.

#### MATERIAL EXAMINED

*Type locality*: Cedar Mills, Adams Co., Ohio (L. and R. Wesson), the holotype and gynetype, taken close together in thin soil cover in brushy woods, somewhat open, grassy spot.

A single additional worker, taken at Woodlawn, Illinois (L. J. Stannard), included in the above description, has the broader head of the two workers, but is obviously of this very distinct species. Returned to INHS. Two workers belatedly received from INHS: Red Hills State Park, Illinois, *Andropogon* sod (Smith and Stannard).

#### SMITHISTRUMA (SMITHISTRUMA) FILIRRHINA Brown

*Smithistruma* (*Smithistruma*) *filirrhina* Brown, 1950, Trans. Amer. Ent. Soc. 76:37-38, worker.

*Holotype worker*: TL 2.17, HL 0.56, WL 0.55, CI 69, MI 22. With the characters of the group. Head a little broader than in *bimarginata*; eyes small and just barely protruding visibly at sides, dorsal view. Alitrunk and rest of body much as in *S. pilinosus*, with same straight profile of posterior dorsum; median carinula strong, ending in an inconspicuous tubercle at the weakly indicated metanotal groove.

Clypeus as broad as or extremely slightly broader than long, free border bimarginate, disc platform-like, concave, or more properly, with a very broad, shallow transverse sulcus centered at the discal midlength. Dorsal free margin cultrate, broadly rounded and somewhat translucent, very feebly scalloped or irregular along part of its edge. Ventral to this margin is a groove running all the way around the free border, and below this is the ventral margin, not so distinctly cultrate as its dorsal companion. In these characters, the clypeus very much like that of *bimarginata*, but a bit more broadly rounded. In the holotype, the only specimen available to me, there is a continuous band of some hardened black substance practically filling the groove of the free border, very even in form and

projecting slightly laterally at each posterior end of the groove just anterior to the lateral clypeal angles. This black material may represent a hardened secretion or some other foreign material, but its evenness and symmetry are such that the possibility of its representing a permanent structure should not be lightly discarded. Clypeus yellowish in color and shining, the tubercles appearing as minute brilliant points and mostly restricted to a narrow belt just inside of and following the free border.

Hairs fringing free border very fine, filiform, extremely slightly or not at all enlarged apically, arranged in a pattern somewhat similar to those of *ornata* and *dietrichi*, though the individual hairs are not so large and conspicuous. Nearly all hairs rising either directly from the dorsal free margin or just inside it, curved more or less away from the midline. Just inside of and posterior to the left lateral corner of the disc, there arises a very long, weak, perpendicularly erect, crooked flagellate hair which is nearly as long as the disc itself. This is apparently paired with a shorter, but similar (broken ?) hair in the same position on the opposite side of the disc. On each side in the same general posterior region of the disc are two or three shorter, but still rather long, weak flagelliform hairs, erect and with their apices curved gently posterolaterally. If the longest hair is normally one of a pair, the correspondence in position and type to the long slender pair of posteromedial vibrissae in *ornata* and *dietrichi* is a possibility. More specimens are needed to aid in the extended definition of the clypeal pilosity.

Pilosity of upper dorsum of head much as in *laevinasis*, very fine, subreclinately arched toward the midline and only moderately abundant. Paired long fine flagellate hairs on the occiput and one hair on each occipital lateral border. Scape hairs 7 or 8, very fine and inconspicuous, slightly enlarged at tips, subreclinate and directed apicad. Alitrunk with very fine hairs, few and mostly reclinate; no outstanding long flagellate hairs, possibly rubbed off. A few long weak hairs on the nodes and on the anterior and posterior gastric dorsum. Basal gastric costulae distinct but fine, extending not more than 1/5 the length of the basal tergite.

Color medium ferrugineous, basal gastric tergite feebly infuscated.

The holotype, a unique, was taken on December 17, 1946, in a Berlese funnel sample of pine-holly leaf mould from Williamston, North Carolina (D. L. Wray); to be deposited in USNM.

#### ORNATA GROUP

Two Nearctic species, *ornata* and *dietrichi*; the aberrant Neotropical *hyphata* is also placed here provisionally. This general characterization applies mainly to the two North American forms:

Head more or less cuneiform, the preocular laminae strongly or not at all convergent. Clypeus longer than broad in most specimens, with the anterior free border rounded or forming a blunt raised point. Clypeal hairs very much specialized, the largest ones very long and prominent, arranged principally in a small group radiating from the center of the disc just behind the free border, not or strongly clavate apically. A pair of long, slender, curved vibrissae arising from the midlength of the disc, one on each side; remainder of disc virtually naked.

The anterior end of the clypeus, including the median portion of the free border, is usually raised to some extent, and the disc is consequently feebly convex or saddle-shaped. Form, sculpture and pilosity of remainder of the body not strikingly different from those of other North American species in the common groups.

Mandibles very slender, with a long diastema, longer than the basal tooth; the latter acute, but not as strongly so as in *clypeata*; only 4 principal teeth in the apical series, showing that the closest relationship is probably with the *pulchella* and *talpa* groups.

*S. hyphata* new species, with a habitus very similar to that of *dietrichi* in many ways, is described with the Neotropical fauna.

Biologically, the two Nearctic species are very interesting, since, though closely related, they seem to have very different nest site preferences. Although both species were considered to be rare twenty years ago, the more recent interest of American entomologists in small cryptobiotic arthropod faunas has brought forth a considerable number of records with accurate and detailed ecological data. These records, while individually insignificant, are most impressive when brought together in showing that *dietrichi* is by strong preference a dweller in rotten logs and under bark of logs and trees, while *ornata* almost invariably nests in the soil cover. The negative evidence is almost as important; Dr. D. L. Wray, an indefatigable collector of Berlese soil samples in North Carolina and very successful in collecting many soil cover dacetines, has not been able to find a single specimen of *dietrichi* among his samples, while he has turned up *ornata* on several occasions. This is not to say that *dietrichi* is never to be found in soil samples, or *ornata* vice versa, for it is entirely possible that these ants often cross the very indefinite borders of their preferred habitats while foraging, or, under unusual circumstances, even in nesting. Nevertheless, the number of records now available is clear in showing great sensitivity in selection of nest sites. The underlying factors, perhaps involving prey-specific preferences, that cause this striking selectivity would make a nice problem in ecology.

Males of the *ornata* group, now unknown, will probably aid in placing the group more accurately in the phylogenetic sequence.

SMITHISTRUMA (SMITHISTRUMA) ORNATA (Mayr)

Text-fig. 7; Pl. I, fig. 2

*Strumigenys ornata* Mayr, 1887, Verh. Zool.-bot. Ges. Wien 37:571 note, worker. *Strumigenys ornata* Emery, 1890, Bull. Soc. Ent. Ital. 22, Pl. 8, fig. 2, worker; 1895, Zool. Jahrb. Syst. 8:328, Pl. 8, fig. 20, worker; Wheeler, 1908, Bull. Amer. Mus. Nat. Hist. 24:148 in key, worker. *Strumigenys* (*Cephaloxys*) *ornata* Emery, 1922, Gen. Ins. Fasc. 174:325; M. R. Smith, 1931, Ann. Ent. Soc. Amer. 24:695-696, Pl. 2, fig. 5, worker; L. and R. Wesson, 1939, Psyche 46:92-93 ("*ornato*"), biology, p. 109, worker, in key. *Strumigenys* (*Trichoscapa*) *ornata* M. R. Smith, 1947, Amer. Midl. Nat. 37:587.

*Worker*: TL 1.95-2.26 (most specimens 2.00-2.10), HL 0.53-0.60, WL 0.47-0.58, CI 65-68, MI 11-13. This is a well-known and easily recognizable species, likely to be confused only with *S. dietrichi*. In *ornata*, the prominent anterior clypeal hairs have thick, conspicuous bulbous swellings at the apical extremities. Examined by bright transmitted light, these bulbs seem to contain a dark core, which may represent a secretion of some sort in storage. Although there is still no positive evidence for the "lure hypothesis," which I have suggested elsewhere in connection with dacetine feeding upon Collembola, the clypeal pilosity of *ornata* is certainly suggestive to human eyes of a clump of small fungal fruiting bodies. In this connection, it must be mentioned that direct visual stimulus, in view of the reduced optic equipment of the majority of Collembola, is doubtfully effective as any part of a possible lure.

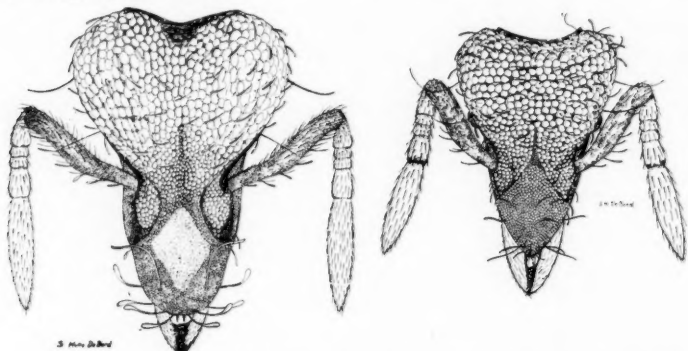
The preocular laminae are usually roughly parallel and more or less convex, and the anterior clypeal border is broadly rounded and distinctly raised. Pronotum with distinct anterior margin, subangulate humeri, and a well developed median carinula extending posteriad across the mesonotum. Promesonotal sulcus not developed; mesonotum with a feeble semicircular subcarinate anterior border. Pronotal sculpture largely effaced, the dorsum as well as the sides usually more or less shining. Metanotal groove only feebly developed, but somewhat enhanced by a weak transverse carinula marking the posterior mesonotal border. Sides of pronotum in most specimens appearing weakly marginate or submarginate. Almost entire sides of alitrunk smooth and shining. Piligerous tubercles of humeri and mesonotum small but distinct. Propodeal teeth acute, slightly elevated,



Lateral border of each occipital lobe with two long, outstanding flagellate hairs; similar paired flagelliform hairs arising from the humeral tubercles and mesonotal tubercles, and also a pair nearer the center of the pronotal dorsum. Hairs of nodes and gastric dorsum moderately abundant, only moderately long, most often not flagellate and appearing truncate at apices.

Color usually medium ferruginous, but lighter or considerably darker individuals are not uncommon.

*Gynotype female*, deplete: TL 2.42, HL 0.61, WL 0.64, CI 67, MI 11. Differing from the worker in the usual attributes of full sexuality. Pronotum with distinct, though blunt, humeral angles. Scutum with a feeble anteromedian impression, also with a distinct median longitudinal carinula and some feeble longitudinal striae or costulae on each side of the carinula. Pro- and mesonotal dorsa with rather abundant short fine flagelliform hairs, mostly slanted or curved posteriad. Basal gastric costulae rather coarse, extending nearly half the length of the basal tergite, with faint shagreening interspersed. Color medium ferruginous, ocellar calluses blackened. Described from a single female taken with workers from forest debris south of Fulton, Tennessee, March 30, 1948 (L. J. Stannard); deposited in INHS.



Text figs. 7, 8.—7. (left) *Smithistruma ornata* (Mayr), worker, head in full-face view (after M. R. Smith); 8. (right) *Smithistruma dietrichi* (M. R. Smith), worker, head in full-face view (after M. R. Smith).

Male unknown. Cotypes in Mayr Coll., probably also in other European collections. Specimens in the Schmitt Collection from St. Vincent College are marked "type." Several of these were destroyed en route to me for study. While the latter specimens, taken near Alexandria, Virginia by Pergande, are probably nidotypic, I doubt whether they were even seen by Mayr.

*Type locality*: "Washington, D. C." (T. Pergande); actual localities probably in Virginia, just across the Potomac River from Washington, for most of the specimens I have seen collected by Pergande were accompanied by a note to this effect.

*Localities for material studied*, mentioned in part only:

ALABAMA: Tuscaloosa (E. O. Wilson); University (B. D. Valentine). The record from Mobile, Alabama (W. S. Creighton) mentioned by Smith in 1931 is based on a specimen of *dietrichi*.

FLORIDA: Welaka (A. Van Pelt); Perry (H. H. Ross and L. J. Stannard).

GEORGIA: Brunswick (Wilda Ross); Atlanta (H. Hoogstraal).

ILLINOIS: Various localities in the southern half of the state, by members of the Illinois Natural History Survey; northernmost state record is Marshall, Clark Co. (Ross, Gloyd and Stannard).

INDIANA: Evansville (H. S. Dybas); Spring Mill State Park (T. Frison and H. H. Ross).

KENTUCKY: Pine Ridge (P. O. Richter and M. W. Sanderson); Burnside (H. H. Ross and L. J. Stannard).

MARYLAND: Near Lloyds (H. S. Barber).

MISSISSIPPI: Louisville (G. W. Haug).

NORTH CAROLINA: Fayetteville, Statesville, Yanceyville (D. L. Wray); Durham (V. E. Shelford); Belmont (P. J. Schmitt); Asheville (A. P. Jacot).

OHIO: Several collections from Pike Co. (L. and R. Wesson).

This species undoubtedly reaches the New Jersey pine barrens, although it has not yet been collected from there. The abundant ecological notes furnished by the collectors mentioned above indicate that *ornata* is most frequently taken in Berlese funnel samples of forest ground cover. Records in connection with large masses of rotten wood are few and indicate that nests of this sort are near or at the soil cover level, e.g., "under rotten stump" or "at base of rotten stump." The Wessons and others have seen nests in crevices in the soil or under stones, and specimens are frequently found in the nests of other, larger species of ants. Series from Berlese funnel batches frequently come mixed with specimens of other soil-dwelling *Smithistruma*, indicating that the ants probably congregate in areas where prey is concentrated or otherwise present under favorable conditions. Because of the commonness of such mixtures of dacetine species, samples containing several of the ants should always be looked at specimen by specimen so that the rarer species, which may be present only singly, will not be overlooked.

#### SMITHISTRUMA (SMITHISTRUMA) DIETRICH (M. R. Smith)

Text-fig. 8

*Strumigenys* (*Cephaloxys*) *dietrichi* M. R. Smith, 1931, Ann. Ent. Soc. Amer. 24:696-697, Pl. 2, fig. 6, worker. *Strumigenys dietrichi* Kennedy and Schramm, 1933, Ann. Ent. Soc. Amer. 26:99-104, figs. 3-14, morphology of worker mouthparts, biology. *Strumigenys* (*Cephaloxys*) *dietrichi* [sic] L. and R. Wesson, Psyche 46:93 (biology) and 108, worker, in key. *Strumigenys* (*Trichoscapa*) *dietrichi* M. R. Smith, 1947, Amer. Midl. Nat. 37:587.

Worker: TL 2.09-2.42 (2.20-2.30), HL 0.55-0.61 (0.57-0.60), WL 0.53-0.60, CI 63-66, MI 13-14. Measurements and description taken from over 100 workers selected from 34 series from Ohio, Illinois, Indiana, Tennessee, Maryland, Alabama, Arkansas, and Florida, including size extremes noticed among total material.

Besides the small average differences in size and proportions as noted above, *dietrichi* differs from the closely related *ornata* in the following qualitative attributes:

(1) Clypeus distinctly diamond-shaped, longer than broad, with anterior border raised and coming to a distinct, more or less apically blunted point; in occasional individuals, the point not so very distinct, but anterior clypeal border at least much more narrowly rounded than in *ornata* or any other species of Nearctic *Smithistruma*.

(2) Head more perfectly cuneiform, the preocular laminae usually distinctly convergent anteriorly and weakly convex, tending to complete a continuous outline from the lateral occipital border to the mandibular apices. Due to the strong anterior narrowing of the clypeus, a considerable basilateral portion of each of the mandibles is left exposed at full closure.

(3) Clypeal hairs placed similarly to those of *ornata*, but much more nearly filiform, with little or no apical swelling. Hairs on alitrunk more abundant than in *ornata*, particularly the smaller ones; long hairs of gastric dorsum decidedly longer than in *ornata*, distinctly flagelliform and weak, arching to or nearly to the surface.

(4) Form and sculpture of alitrunk much as in *ornata*, except that the dense punctulation of the pronotum is as distinct, including the side pieces, as is that of the head and mesonotum; promesonotal sulcus often feebly developed; some specimens with very feeble subrugulation in a longitudinal direction on the pronotum.

Color ferrugineous, usually in medium shades; gaster a little darker and more brownish, sometimes very deep brown.

Gynotype female, dealate: TL 2.57, HL 0.62, WL 0.67, CI 65, MI 14. Showing the usual full sexual attributes. Mesonotum with a weak anterior pit or depression in the middle; median carinula present; scutum and scutellum both with longitudinal rugulation. Hairs on thoracic dorsum fine, abundant, of moderate length, suberect to erect. Dense, very fine silvery appressed hairs on the postpetiolar dorsum, especially toward the sides, more noticeable than in the workers. Basal gastric costulae very coarse, half the length

of the tergite bearing them. Gynotype a solitary taken at Bryce Lake, Tuscaloosa Co., Alabama (E. O. Wilson). Several other females (paragynotypes) seen varied but little from the gynotype, and all were deep ferruginous, with ocellar area blackened and alitrunk dorsum and middle of gaster lightly infuscated.

Male unknown. *Lectotype* (designated from Smith's series of 7 workers, originally called cotypes) fixed as the specimen placed in the tray reserved for holotypes in USNM, fixation present. Other specimens from the original series are presumably in the collection of the Mississippi A. and M. College. Female types are in MCZ and other North American collections.

*Type locality*: Lucedale, Mississippi (H. Dietrich), in woody frass of logs and stumps.

*Distribution and material examined*: 34 series and numerous strays of this ant were examined, making a list so voluminous that it is omitted here in a locality-by-locality sense. Localities at the extreme of the range as presently known are cited with collectors: Illinois: numerous collections from rotten logs of all sorts of trees in the vicinity of Urbana and other southern and central portions of the state (personnel of the Illinois Natural History Survey; Orlando Park). Harahan, Louisiana, single female, under bark of willow (F. G. Werner). Washington Co., Arkansas (M. W. Sanderson). Several localities in northern Florida (A. Van Pelt; P. J. Schmitt). "Maryland" (T. Pergande). North of Columbus, Ohio (M. E. Amstutz). Within this large area of the eastern United States, and probably also in the New Jersey pine barrens, *dietrichi* occurs in pretty much the same localities as mentioned under *ornata*, and has been taken by very nearly all the same collectors. A notable hiatus occurs in North Carolina, where Dr. D. L. Wray, an active and very successful collector of dacetines by means of soil cover Berlese funnelling, has so far failed to take this species. Since *dietrichi* almost certainly occurs in North Carolina, the lack of specimens from Dr. Wray merely confirms the high degree of preference shown by this ant for a habitat other than the soil cover.

The majority of records, both in the literature and among those sent to me with specimens, are specific in stating that the ants were taken under the bark of logs, stumps or standing trees, while a lesser number indicate that the actual nest was deeper in the log or stump than the cortical or subcortical layers. *Dietrichi* sometimes occurs in or near nests of other ants.

#### PULCHELLA GROUP

Three Nearctic species are presently considered valid: *pulchella*, *missouriensis* and *reflexa*. Size rather small, but not so small as previous authors have stated. Head with definitely expanded occipital lobes and parallel or subparallel preocular laminae, so that the cuneiform shape characteristic of the *clypeata* group is lost. Clypeus definitely broader than long and more than half as broad as the head across the occipital lobes, its free border with one visible margin, and this usually more or less bluntly tuberculate, so that it appears shallowly and irregularly scalloped in many specimens. The clypeal disc is more or less impressed or shallowly concave, minutely granulose-punctulate and opaque, with pilosity in the center very much reduced, appressed or subappressed and inconspicuous, often absent altogether. The hairs of the free border proper are few in number, usually 4-6 on each side of the midline; with the exception of one or two minute pairs in the middle of the anterior portion, these hairs well developed, spatulate or spoon-shaped. Usually at least one of the hairs on each side is turned laterally and more or less posteriorly, and in typical *reflexa* specimens, all the free border hairs are so directed. A smaller row of suberect, apically broadened hairs is usually fairly distinctly seen on the disc just inside of and following the free margin.

Mandible short, with an acute basal tooth and a large diastema; four principal teeth in the apical series. Alitrunk much like that of other North Ameri-

can groups. Postpetiole and gaster shining, the latter with distinct basal costulae and some long weak hairs.

The taxonomy of this group is less clear than in any other Nearctic complex except, perhaps, in the *clypeata* group. The species are separated on width of head and mandibles and on relatively minor differences in amount, size, shape and direction of curvature of pilosity, especially that of the clypeus. All would be well were it not that these very attributes are variable to some extent and apt to intergrade in occasional specimens. The most variable species is *missouriensis*, which I here take to include *sculpturata*, but even this variable form has limits separating it fairly well from *pulchella* on the one hand. The two forms *pulchella* and *missouriensis* seem readily distinguishable at a glance, no matter from what locality they stem, even though drawing a formal line in description is a difficult matter involving some rather picayune characters. *Missouriensis* may be said to be intermediate between *pulchella* and *reflexa* in pilosity and in general robustness of build. While *reflexa* series or individuals from most localities are readily identifiable because of the reflexed condition of all the principal hairs fringing the sides of the clypeus, there exists one North Carolina series containing individuals clearly intermediate between *reflexa* and *missouriensis* in the number of hairs reflexed. The separateness as species of these two forms therefore comes into question.

I have tried my best to fit all the specimens conceivably identifiable as *missouriensis*, *reflexa* or Smith's *sculpturata* into some sort of pattern of geographical races or races and species, and at times have seemed to find a successful answer to the problem in this way. Each of the detailed solutions, however, has sooner or later been completely wrecked by specimens sent me by cooperators from such localities that the distributions are shown quite clearly to overlap on so broad a scale that notions of subspeciation for any and all of these forms cannot now be accepted. Because, in all of the known localities but one, *reflexa* stands out and is easily identifiable, I have retained it as a separate species until proper ecological and breeding studies can be made upon living samples. In the case of *sculpturata*, which is not distinctly different from *missouriensis* in the first place, I have as complete a series of gradually intergradient forms from recent new collections as will serve to satisfy anyone that a large percentage of available specimens can be placed as either species with little difficulty. In the face of such intergradation, the only course possible seems to be synonymization of *sculpturata* under *missouriensis*. Collections of the *missouriensis-reflexa* complex accompanied by accurate and detailed breeding data will be needed to help in settling the final details in the taxonomy of the forms of this group.

Grounds can be found for relating the *pulchella* group to almost every other group occurring in its region, but among these, linkage to the *talpa* group, the *ornata* group, and possibly through *abdita* to the subgenus *Wessonistruma* appears strong on the basis of the reduction to 4 of the number of principal teeth in the apical series. On the other hand, similarity in head form to the *rostrata* group is marked, and probably indicates a relationship through partially diastemate forms like *bunki*.

*Pulchella* is a common species in the eastern half of the United States, usually nesting in red-rotten logs or the red rotsoil collected in the bases of

hollow trees, though apparently it is also a soil-nester at times. The other two species appear to nest chiefly in the soil, although *missouriensis* will nest in rotten wood, and so few records are known for the latter species that it is perhaps not safe to generalize concerning them.

SMITHISTRUMA (SMITHISTRUMA) PULCHELLA (Emery)

*Strumigenys pulchella* Emery, 1895, Zool. Jahrb. Syst. 8:327-328, Pl. 8, fig. 19, worker. *Strumigenys pulchella* Wheeler, 1908, Bull. Amer. Mus. Nat. Hist. 24:148, worker, in key; Kennedy and Schramm, 1933, Ann. Ent. Soc. Amer. 26:95-96, 100, biology. *Strumigenys (Cephaloxys) pulchella* Emery, 1922, Gen. Ins. Fasc. 174:325; M. R. Smith, 1931, Ann. Ent. Soc. Amer. 24:702-704, Pl. 4, fig. 13, worker, biology; L. and R. Wesson, 1939, Psyche 46:100-101, biology; Buren, 1944, Iowa State Col. Jour. Sci. 18:290. *Strumigenys (Trichoscapa) pulchella* M. R. Smith, 1943, Amer. Midl. Nat. 30:307; 1947, Ibid. 37:587. *Smithistruma (Smithistruma) pulchella* Brown, 1948, Trans. Amer. Ent. Soc. p. 104, designation as genotype of *Smithistruma*.

*Worker*: TL 1.96-2.10. Concerning total length, Emery gives "1 1/2-1 2/3 mm." Smith follows Emery with "1.5-1.66 mm." Out of 400 individual workers from all parts of the known range examined, I was able to find only six individuals measuring under 2.00 mm. Even allowing for differences in method, this great difference in the dimensions for so small an insect points up the necessity for at least a modicum of accuracy in future measurements. HL 0.52-0.61, CI 61-67, MI 12-17.

This species has been amply described in the worker caste by both Emery and Smith; the figure given by Smith (1931) shows the habitus of a typical specimen very well if the too-great thickness of the scapes be ignored. This is a familiar form to most American myrmecologists, and is represented in most European and American collections. The clypeal pilosity varies slightly from one nest to another; in some series, the hairs on the anterior border are all curved more or less toward the midline, or at least, there are none curved definitely away from the midline. In most series, however, one large hair on each side of the anterior border and the one or two very small pairs in the center of the border are laterally curved. The hairs on the disc proper are usually present throughout, but are very inconspicuous and mostly appressed, few in number. The lateral border of each occipital lobe bears a long, fine flagellate hair, curving laterally and dorsally.

Sides of closed mandibles not continuing the outlines of the sides of the clypeus; mandibular diastemata large, sometimes seeming to take up half the visible length of the inner border. The shafts of the mandibles are very small and slender, and only very weakly convex dorsally.

Anterior pronotal border narrowly rounded, without or with very indistinct humeral angles; pronotum without or with weak, incomplete lateral marginulae, but with a more or less distinct median longitudinal carinula continuing back across mesonotum. Mesonotum bounded anteriorly by an indistinct sulcus and laterally by fine cariniform margins continuing along dorsolateral borders of propodeum. Metanotal groove narrow and rather weak. Sculpture of pronotum often partially effaced, subopaque; sides of alitrunk almost completely smooth and shining. Color varying from light to deep ferruginous.

Smith's 1931 description states that the clypeal hairs are "club-like." In my opinion they are curved-spatulate or narrowly spoon-shaped, but not clavate. Specimens from the Gulf States are definitely smaller than those from the northern parts of the range. Alabama and Mississippi specimens usually show HL 0.52-0.56, while series from stations ranging from New Jersey to Illinois most often have HL 0.58-0.61; proportions remain about the same. Series from intermediate points like Virginia and Tennessee show dimensions exactly intermediate and overlapping both northern and southern populations. Study of the material available indicates that variation in size runs according to a gradual north-south cline. Since there is at least some evidence (see below) that the related species *reflexa* acts in the same way over the same territory, I am inclined to think that the size variation is more ecological than genetic. Not only does *pulchella* (and some other *Smithistruma* species) get smaller in the extreme South, but it also seems to occur with lesser frequency in Florida and southern Alabama than in states like Illinois, Maryland and Pennsylvania. It may be that the populations along the Gulf Coast are the impoverished outposts of an essentially temperate-climate species now expanding its range.

*Gynotype* female, dealate: TL 2.50, HL 0.60, WL 0.63, CI 67, MI 15. Except for full sexual characters, much as in the worker. Hairs on anterior clypeal border all curved medially. Longitudinal costulation of scutum distinct and rather coarse. Meso- and metapleura and sides of propodeum smooth and shining. Basal gastric costulae rather coarse, extending  $1/3$  or slightly more the length of gastric tergite I. Hairs on dorsum of alitrunk, nodes and gaster very fine, flagellate or subflagellate, rather abundant and mostly slanted or curved posteriad. Color medium ferruginous, ocellar triangle infuscated. *Gynotype* taken singly at Harahan, Jefferson Parish, Louisiana, Nov. 15, 1944 (F. G. Werner); deposited in MCZ.

*Paragynotype* females from Ohio, Illinois and Pennsylvania: TL 2.45-2.54, HL 0.60-0.62, WL 0.64-0.65, CI 67-68, MI 15. The outward curving of 2, 3 or 4 of the hairs along the free clypeal border is not so common or pronounced in the females as in the majority of worker series, but the females do vary among themselves in this respect. Longitudinal costulation varying in strength and general body color varying in depth.

*Allotype male*: TL 2.36, HL 0.50, WL 0.76, CI ca. 76, eyes excluded from measurement. Full length of a mandible ca. 0.14 mm. Forewing L ca. 2.7 mm. Mandibles much reduced, smaller and less projecting than under-mouthparts. Much like the same sex of *talpa*, eyes large and strongly convex. Scutum finely and closely longitudinally striate. Posterior sides of alitrunk weakly shagreened and feebly shining, center of kat-episternum strongly shining. Propodeal teeth reduced to low obtuse dentiform angles above, subtended by very narrow, whitish carinae below. Petiolar node longer than its peduncle, anterior face very gently sloping, summit rounded above and broader than long, about  $4/5$  as broad as the postpetiolar node. Both nodes smooth and shining above, with spongiform appendages arranged as in the worker, but reduced to insignificant whitish cariniform vestiges. Gaster without basal costulae, smooth and shining. Head and anterior alitrunk black or very nearly so, appendages, mandibles and genitalia dull ivory yellow, remainder of body dark castaneous. Forewing venation much reduced, only  $R + Sc$ ,  $R_{5+6}$ ,  $Mf_1$ , stigma,  $CU + M$  and  $2r$  defined at all, colored lightly with straw pigment; main branches of  $M$  and  $Rs$  present only as grooves. *Allotype* (MCZ) taken from a nest with females and workers at White's Gulch near Jackson, Ohio (L. and R. Wesson), no date given. Other males have been seen from Southern Ohio and Tennessee; sculptural and other external details are apparently variable, even within one nest series. The volsellae are like those of *talpa* and *reflexa*. *Allotype* in MCZ; paratype males in various other North American collections.

*Type locality*: Emery cited Washington, D. C. and Beatty, Pennsylvania as original localities. While the collections were credited to Pergande, I believe that the series from Beatty is properly credited to P. J. Schmitt, in whose collection exist several pins of this ant with Beatty labels and his own name as collector. Schmitt frequently exchanged specimens with Pergande and directly with various European authors. Unless Dr. Creighton has fixed the type locality otherwise, I suggest that Washington, D. C. be selected for this purpose, with Pergande as type collector.

*Distribution and other remarks*: I have examined over 400 specimens of this ant more or less carefully to gain an idea of the variation in all parts of the range. Represented was material from 51 separate colonies, and numerous single strays were seen as well. Many more hundreds of specimens were identified hurriedly. There are numerous records in the literature accompanied by good data on feeding habits, nesting sites, etc., and investigation is still being carried on by several specialists. There seems to be no point in stating formally the voluminous records. The ant undoubtedly occurs in every state east of the Mississippi and south of a line connecting New York City, Cleveland and Chicago. Wide distribution in wooded areas west of the Mississippi is indicated by the Harahan, Louisiana (F. G. Werner) and Ames, Iowa (W. Buren) records; it probably occurs in many river bottoms extending into the Great Plains.

In Florida, it has been taken at Welaka in the northern part of the state (A. Van Pelt); it is common in red-rotten logs and stumps in southern New Jersey and the Philadelphia area (K. W. Cooper, W. L. Brown); and it must certainly occur farther north along the coast, although the single record from Long Island (see M. R. Smith, 1931, p. 703, and also under *missouriensis* below) is based on a misdetermined specimen of *missouriensis* in Dr. Creighton's collection.

This ant definitely seems to prefer to nest in large masses of rotten wood, and although it will on occasion nest in the ground, I suspect that it does so chiefly in areas in which



the normal and original supply of rotting logs has been removed by human activities. It is a feeder on collembolans, and is a relatively inactive huntress. The best summary of its biology published to date is that of the Wessons, cited in the synonymy.

SMITHISTRUMA (SMITHISTRUMA) MISSOURIENSIS (M. R. Smith)

Text-fig. 9, Pl. I, fig. 7

*Strumigenys* (*Cephaloxys*) *missouriensis* M. R. Smith, 1931, Ann. Ent. Soc. Amer. 24:701-702, Pl. 4, fig. 14, worker. *Strumigenys* (*Cephaloxys*) *missouriensis* L. and R. Wesson, 1939, Psyche 46:101 (variation, biology), p. 111, in key. *Strumigenys* (*Cephaloxys*) *sculpturata* M. R. Smith, 1931, Ann. Ent. Soc. Amer. 24:706, Pl. 4, fig. 15, worker; L. and R. Wesson, 1939, Psyche 46:110, in key. (new syn.) *Strumigenys* (*Trichoscapa*) *missouriensis* (and *sculpturata*) M. R. Smith, 1947, Amer. Midl. Nat. 37:587.

*Worker*: TL approximately as in *pulchella*; HL 0.54-0.61, CI 67-72, MI 13-18. Measurements from 42 specimens representing at least 12 different colonies, including the type series and specimens from all the localities listed below.

Close to and resembling *pulchella*, but the head and mandibles broader and the mandibular diastema often less distinct. Differences in general form and pilosity of the head are well illustrated in Smith's 1931 revision in his Plate 4, where *pulchella* is represented by fig. 13, and what I consider to be *missouriensis* by his figures 14 and 15. With Dr. Smith's kind aid, I have used the figure of the *missouriensis* cotype in this work (my text-fig. 9). In using Smith's figures, allowances must be made for certain discrepancies in the thickness of the antennae and in the mandibular dentition shown in insets.

The center of the clypeal disc has a rather large space totally without hairs, or with hairs so reduced that they are invisible at magnifications of 175 $\times$  in good light. There are usually one or two rows of small spoon-shaped hairs, suberect and rather inconspicuous, situated on the disc just inside the free border; these are most often directed laterally or even posteriorly. There is great variation both within and between different nests as regards the number and degree of development of both the intramarginal and marginal hairs, and this variation extends to the shape of the clypeus, which may be broadly and rather smoothly rounded anteriorly or rather irregularly and bluntly scalloped with a subtruncate or truncate anterior border. All degrees of intergradation can be found to link the extremes. There is also variation of very slight degree in the convexity and robustness of the mandibles, but differences here are often illusory and are affected by the completeness of mandibular closure. The relative breadth of the head varies slightly and is intermediate between the breadths of *pulchella* and *reflexa*, but I have found no significant differences between CI's of specimens from Smith's original series of *missouriensis* and *sculpturata* in this respect.

Upper dorsum of head more or less distinctly tuberculate, the tubercles bearing more or less stiff, erect hairs with blunt tips; lateral occipital hairs never so long and finely tapered as in *pulchella*.

The alitrunk is perhaps slightly more robust than is that of *pulchella* and has more definite humeral angles and usually more distinct dorsolateral pronotal margins. Most hairs of the alitrunk show a tendency toward apical truncation or extremely weak clavation.

*Female*: Dr. Smith did not describe the females he stated to be present in the type nest. The statement that they were winged, coupled with the definite knowledge that they were taken in the same nest as the type workers and were stated by Smith to be of the same species, should in this case be accepted as the original female description for purposes of type fixation. It is desirable to have the gynetype, where found in the same nest as the worker type, designated with its colony so as to prevent possible confusion at a later date. The specimens mentioned by Smith will have to be considered *cogynetype*s until a definite specimen is picked to represent this caste.

Four female specimens, all dealate, from Pike Co., Ohio; Harmony, North Carolina and Black Pond, Virginia: TL 2.47-2.58, HL 0.61-0.62, WL 0.64-0.66, CI 71-75, MI 14-17. Similar to the worker cotypes of *missouriensis*, showing the usual full sexual differences. Posterior half of scutum flat, with a few separated longitudinal rugulae. Erect alitrunkal hairs fine, but with very feebly clavate or at least truncate tips. Color medium ferrugineous.



Male unknown, probably similar to that of *pulchella*

**Material examined:** I have listed the specimens known previously in one list and the specimens upon which new records are based in a second. After the collector's name in the case of previously known specimens, I have given the previous determination placed upon the specimens, and the author and date of citation. All of the localities listed represent examinations of at least one example by the present author. All specimens are considered to belong to *missouriensis*.

Aberdeen, Mississippi (M. R. Smith), *sculpturata* Smith, 1931, cotypes.

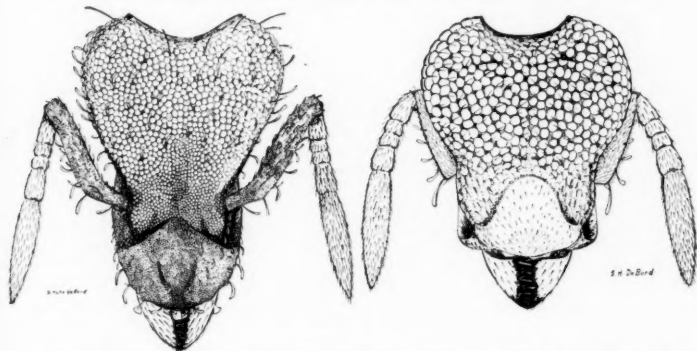
Ripley, Mississippi (S. W. Simmons), *sculpturata* Smith, 1931.

Black Pond, Fairfax Co., Virginia (W. M. Mann), *sculpturata* Smith, 1931.

Columbia, Missouri (Mary Talbot), *missouriensis* Smith, cotypes, type locality.

Pike Co., Ohio, several colonies (L. and R. Wesson), *missouriensis*, L. and R. Wesson, 1939.

Forest Hills, Long Island, New York (L. F. Barnum), *pulchella*, Smith, 1931.



Text figs. 9-10.—9. (left) *Smithistruma missouriensis* (M. R. Smith), worker, head in full-face view (after M. R. Smith); 10. (right) *Trichoscapa membranifera* Emery, worker, head in full-face view after M. S. Smith).

#### NEW RECORDS

Falls Church, Virginia, in moss (F. André).

Statesville and Harmony, North Carolina, both collections in leaf mould (D. L. Wray).

Collection records of *missouriensis*, while still too few to be conclusive, indicate that it is primarily a soil and soil cover inhabitant. Mary Talbot collected the types in a nest of *Aphaenogaster fulva* under a stone in clay soil. The Wessons found this species abundant in the humus of a cedar thicket in southern Ohio; their work should be referred to for biological notes. Smith states that he collected workers under bark of logs and stumps (*sculpturata* cotypes), although some of the original workers were taken under objects lying on the soil surface. Miss Talbot took winged females from the type colony on August 20, 1929, the usual time of year for winged forms to occur in the nest.

Types of *missouriensis* are on deposit in the USNM and MCZ, and specimens of nearly all the series mentioned are present in the collections of one or both of these institutions.

#### SMITHISTRUMA (SMITHISTRUMA) REFLEXA (L. and R. Wesson)

*Strumigenys* (*Cephaloxys*) *reflexa* L. and R. Wesson, 1939, Psyche 46:102-103, 111, Pl. 3, fig. 4, worker description, biology, key. *Strumigenys* (*Trichoscapa*) *reflexa* M. R. Smith, 1943, Amer. Midl. Nat. 30:307; 1947, Ibid. p. 587.

**Worker:** TL 1.95-2.39 (usually 2.05-2.15), HL 0.52-0.59, WL 0.50-0.58, CI 70-76, MI 16-19, and a strongly nanitic worker from Tuscaloosa, Alabama (E. O. Wilson),

representing the southernmost known record: TL 1.76, HL 0.48, WL 0.46, CI 78, MI 16. The measurements are from 53 workers representing at least 12 separate colonies from Ohio, Illinois, Tennessee, North Carolina and Alabama, including size extremes from among over 250 specimens examined.

Head averaging a bit shorter and broader than that of *missouriensis*, and the anterior clypeal border and verticociput a bit more strongly tuberculate. Center of clypeus bare of hairs, one marginal row of 3 or 4 large, spoon-shaped hairs on each side, all directed posterolaterally; small intra-marginal hairs in one row, also directed posteriorly. Occasional specimens in normal nest series may have one or two of the large marginal hairs curved anteriorly, in this respect making a transition to *missouriensis*. Such specimens come from nests in which most of the workers have the normal *reflexa* pilosity, and have so far been found only in North Carolina and Virginia. Directly dorsal to the antennal insertions, each frontal carina bears on its broadened part a short, broad, reclinate spoon-shaped hair. The hairs on the upper dorsum of the head, arising from the low piligerous tubercles already mentioned, are mostly well spaced, suberect or erect and conspicuous, their apices spoon-shaped or otherwise thickened; posterior occiput with a transverse row of 4 fine, erect bristle-like hairs, the apices of which are very slightly enlarged; a slightly elongate slender spatulate hair on the lateral border of each occipital lobe.

Alitrunk in profile with an obtusely rounded angle formed at the juncture of pronotum and mesonotum; posterior mesonotal area feebly concave; metanotal groove very shallow. The pronotum has distinct anterior and weak dorsolateral margins, but its median carinula is very feeble or absent. Anterior mesonotal border varying in distinctness. Propodeal teeth short, acute, elevated, the infradental carinae broad, with a small excision just below the teeth, but broadly convex ventrally. Dorsum of pronotum usually with punctulation more or less effaced, subopaque or weakly shining. Sides of alitrunk largely smooth and shining. Alitrunk dorsum with a very few small, subreclinate, spatulate ground hairs and some larger, erect paired spatulate hairs, the largest pair on the pronotal dorsum and 4 shorter pairs on the mesonotum, 2 of the latter pairs posterior. A long flagellate or subflagellate hair on each humeral angle, and sometimes the longest hair on each side of the mesonotum is subflagellate, but more often it is erect and stiff. Hairs of nodes and gaster erect, long and slender, but usually truncate or even weakly enlarged at apices. The basal gastric costulae are  $\frac{1}{4}$  or a little more the length of the basal tergite. Color usually light to medium yellowish ferrugineous, rarely darker.

*Gynotype female*, deolate: TL 2.25, HL 0.54, CI 76, MI 18. With the usual differences from the worker. A few oblique rugulae on the occipital lobes. Mesonotum with an extremely feeble median anterior sulcus, a median carinula, and a faint suggestion of longitudinal striation. Gastric costulae coarse, extending about half the length of the basal tergite. Mesonotum with fairly abundant, moderately long, stiff erect hairs, the apices of which are feebly enlarged. Humeri subangulate, with crooked flagelliform hairs. Color yellowish ferrugineous, ocellar calluses blackened.

*Gynotype* described from a specimen taken at Reelfoot Lake, Tennessee (L. J. Stannard), deposited in INHS.

*Paragynotype*; deolate solitary female collected at Fayetteville, North Carolina, May 8, 1949 (D. L. Wray): TL 2.55, HL 0.59, WL 0.62, CI 72. Color medium ferrugineous.

*Allotype male*: TL 2.20, HL 0.46, WL 0.68, CI 88. Greatest diameter of eye 0.19 mm., mandible L 0.12, distance from mandibular insertion to anterior border of eye .05 mm. Wings crumpled, but what can be seen of venation is much as in *pulchella*. Mesonotum with a weak anteromedian impression and a median carinula, but not striate; notauli distinct almost to center of V. Humeri bluntly angulate, each with a flagellate hair. Meso- and metapleurae practically completely smooth and shining. Propodeal dorsum with punctulae in fine transverse rows, but not strictly striate. Propodeal teeth reduced but acute, carinae below very weak. Both nodes nearly entirely smooth and shining.

Clypeus with only a few small fine hairs restricted to sides of free margin. Hairs on cephalic dorsum few, small and fine; those anterior to ocelli directed mesoposteriorly, those posterior to ocelli directed forward. Alitrunk with a few fine hairs, most of which are reclinate. Hairs absent or nearly so on nodes and anterior  $\frac{3}{4}$  of gastric dorsum. Spongiform appendages of nodes developed only as vestigial cariniform borders. Color

deep ferrugineous; head, dorsum of alitrunk and middle dorsum of gaster slightly infuscated. Volsellae as in *talpa*.

Allotype taken from a colony at Catawba on the Lake Erie Shore of Ohio, August 18, 1938 (Mary Talbot); in MCZ.

#### MATERIAL EXAMINED

Types taken by L. and R. Wesson at Jackson, Ohio. Holotype and paratype in MCZ, paratypes in USNM and various other collections.

ALABAMA: Hurricane Creek, Tuscaloosa Co., a single nanitic worker (E. O. Wilson).

ILLINOIS: Several localities in the central and southern parts of the state, collections by personnel of the Illinois State Natural History Survey. Northernmost state record is Quincy (C. C. Hoff).

NORTH CAROLINA: Leggetts; Fayetteville (D. L. Wray).

OHIO: (See above for type locality) Beach at Catawba (Mary Talbot).

TENNESSEE: Reelfoot Lake (L. J. Stannard). Holston Mts. in Sullivan Co. (J. W. Jones).

WEST VIRGINIA: Dr. M. R. Smith (*in litt.*) reports specimens from an apple orchard at Kearneysville (H. A. Jaynes); I have not examined these specimens.

**Biology:** The Wessons observed *reflexa* feeding upon collembolans; according to them, it is a very sluggish huntress. Nesting has been reported from the soil and from under or in objects lying on the soil surface.

**Remarks:** *Reflexa* appears not to have been taken at the same localities as has *missouriensis*, although the general range of the two forms is approximately the same. This may mean that the two are nothing but local populations of the same species, varying by habitat type. The appearance of *reflexa*, however, with its 3 or 4 heavy back-turned clypeal hairs on each side and its relatively broad head, is so different from that of the usual *missouriensis* worker that the two forms should be regarded as separate until further evidence is in. The only other species that might be mistaken for *reflexa* is *wrayi* new species, but the latter may be distinguished by its *talpa*-like head and the abundant small hairs on the disc of the clypeus.

#### TALPA GROUP

Four species, *talpa*, *creightoni*, *wrayi* and *flitalpa*, with similar form of head and mandibles. Clypeus weakly convex, free border unimarginate, the disc about as broad as long or very slightly broader than long and about half as broad as the width of the head across the occipital lobes. Occipital lobes slightly expanded, the cephalic index averaging a little greater than in the *clypeata* group. Preocular laminae parallel or weakly converging anteriorly, but never converging as sharply as in the *clypeata* group. While some specimens therefore show a somewhat cuneiform head, close examination will reveal that in the majority of cases the outline of each side is not perfectly continuous from rounding of occipital lobe to apices of closed mandibles. Mandibles depressed, the mandibular index usually less than 20; toothless diastema distinct and as long as or longer than the length of the acute basal tooth. Principal teeth of apical series 4 in number. The best figure for general habitus of head and mandibles is that of *creightoni* given in Smith's 1931 paper, although in this connection it must be remembered that the pilosity differs markedly with the species. In this figure, as in most of the others in the 1931 paper, the antennae are drawn a bit too thick.

The anterior clypeal border seen under liquid is broadly and evenly rounded, and at higher magnifications is seen to bear small tubercles from which the bordering hairs spring. The surface of the clypeal disc is always opaque, though sometimes the small anteromedian tumulus is fairly smooth and shining. The hairs are abundant and distributed over the entire discal surface, though usually shorter in the middle; the hairs fringing the free

border are more numerous and crowded than in the *pulchella* group.

The species of this group show a series of pilosity developments roughly paralleling that of the *clypeata* group, and already several authors have been confused by the similarities between the two species *clypeata* and *talpa*, each respectively the commonest species in its group. It is possible that the new species *filitalpa*, described below, will be confused with *pilinasis* or *laevinasis*; if specimens are in doubt, the mandibular dentition usually furnishes a safe means of identification to group.

The remainder of the body is slender and much as in other Nearctic species of the group in all respects.

The relationships of this group are not with the *clypeata* group. Wesson and Wesson were misled by Weber's statement that *talpa* belonged to the *clypeata* group, and were also thrown off by his habitus figure of the *talpa* head, which does not bear a very good resemblance to the holotype specimen from which it was drawn. Because of this, the synonymous species *venatrix* was described. Dr. L. G. Wesson has recently pointed out this synonymy after seeing the type of *talpa*, and I fully agree with his action in this case. Due to the "intermediate" habitus and pilosity of *talpa* and its relatives, the greatest number of misdeterminations of our North American fauna have involved one or more species of this small assemblage. In earlier phases of my work with the group, specimens which I had trouble identifying because of seeming lack of determinate characters nearly always turned out in the end to be *talpa*.

From the structure of the worker mandibles and of the genitalia and other characters of the male, I take it that the closest relatives of *talpa* are the species of the *pulchella* group. Smith and the Wessons have also indicated this relationship in their papers on the Nearctic fauna.

*Talpa* itself is a common species in many regions, and is quite definitely a soil or soil cover dweller. Furthermore, the observation of the Wessons that this species prefers open, more or less grassy nest sites has been amply borne out by numerous additional records. The other *talpa* group species are rare, and little is known of their biology, possibly because they are also predominantly dwellers in open grassy places not previously thought to be good areas for collecting dacetines. In reviewing biological records generally for dacetine collections in several genera, I find a surprising number of instances of captures from Berlese funnel samples in rich grass sod far from forested areas.

SMITHISTRUMA (SMITHISTRUMA) TALPA (Weber)

Pl. I, fig. 5; Pl. III, fig. 31

*Strumigenys* (*Cephaloxys*) *talpa* Weber, 1934, *Psyche* 41:63-65, fig. 1, worker. *Strumigenys* (*Cephaloxys*) *talpa* L. and R. Wesson, 1939, *Psyche* 46:109, worker, in key. *Strumigenys* (*Cephaloxys*) *venatrix* L. and R. Wesson, 1939, *Psyche* 44:103-106, Pl. 3, fig. 5, worker, biology. *Strumigenys* (*Trichoscapa*) *venatrix* M. R. Smith, 1943, *Amer. Midl. Nat.* 30:307; 1947, *Ibid.* 37:587. *Strumigenys* (*Trichoscapa*) *talpa* M. R. Smith, 1947, *Amer. Midl. Nat.* 37:587. *Smithistruma talpa* L. G. Wesson, 1949, *Psyche* 56:21, *venatrix* syn.

Worker: TL 2.01-2.41, HL 0.52-0.61, WL 0.49-0.60, CI 67-72, MI 16-19. 35 specimens measured from at least 20 separate colonies representing all the states listed below, including the holotype and size extremes from among more than 200 individuals

examined. Size of workers averaging slightly greater in Illinois and Ohio than in the Gulf States.

Head with a shallow impression running transversely across the dorsum at the level of the antennal insertions. Head shape in general as described for the group, disagreeing with Weber's figure in that the mandibular external borders do not continue the sides of the head. Mandibles as described for the group; basal lamella with a broad base, but fairly acutely tipped, the diastema following rather shallow, longer than the length of the basal lamella. There are 4 principal teeth in the apical series, of which the second is the longest and the third shortest. Teeth 5, 6 and 7 of the apical series much reduced, scarcely larger than the preapical denticles.

Antennal scapes (L 0.26-0.28) bent obtusely near the basal third, slightly incrassate, thickest just distad of the bend. Funiculus (L 0.38-0.40) with apical segment making up slightly more than half the length.

Alitrunk slender, anterior pronotal margin rather narrowly rounded, humeral tubercles at most very feebly developed. Promesonotal sulcus sometimes present, but weak, the anterior mesonotal border often marked by a very indistinct semicircular carinula. Profile from anterior mesonotum to bases of propodeal teeth approximately straight; metanotal groove very narrow and feebly depressed. Promesonotum with a delicate but distinct median carinula; lateral mesonotal tubercles distinct, low and obtuse. Propodeal teeth delicate, compressed, with strongly acute apices, divergent, usually a bit more than half as long as the distance between centers of bases. Infradental lamellae quickly becoming narrow and concave below the teeth, not or just barely widened at their ventral extremities.

Sculpture of the usual pattern; pronotum evenly and densely punctulate and opaque, often with a faint superimposed suggestion of longitudinal striation; posterior sides of alitrunk largely smooth and shining, postpetiolar disc entirely so. Basal gastric costulae rather coarse, extending  $1/3$  or a little more of the length of the basal tergite.

Pilosity rather distinctive. Ground hairs of dorsum of head fine, filiform to subfiliform, some, especially more anteriorly, with feebly enlarged apices, mostly subclinate and directed mesad. Six to eight hairs similar to those of the head on anterior scape borders, all curved toward the scape apex. Clypeal disc with abundant inconspicuous pilosity consisting of small sublinear-spatulate hairs, mostly subappressed and distributed rather evenly. Free clypeal margin with a fringe of projecting, anteromedially curved, narrow linear-spatulate hairs, 9-12 on each side of the middle of the anterior curve. These hairs are a little broader than as shown in Weber's figure, but not quite so broad as the corresponding hairs in *clypeata*. They are often a trifle wider, with a slight tendency toward a spoon-shaped form, in the slightly smaller-sized series from the far southern part of the United States, but the difference is insignificant and not definitely constant within single nest series. A pair, sometimes two pairs, of long fine flagellate hairs on the posterior occiput, also one of these on each lateral occipital border. Alitrunk with moderately abundant, very fine and mostly subclinate or reflexed flagelliform ground pilosity; humeral and lateral mesonotal paired flagelliform hairs very long and fine. Nodes and gastric dorsum each with a few long fine flagellate hairs.

Color varying degrees of ferrugineous, usually medium ferrugineous, with faintly darkened gaster.

*Gynotype female*, alate: TL 2.52, HL 0.60, WL 0.66, CI 67, MI 19. Differing from the worker in the usual full sexual differences. Humeral angles weakly and bluntly developed. Mesonotum with an anterior median depression or sulcus, rather weakly developed in this instance; median carinula and a few longitudinal rugulae also present. Propodeal teeth short, infradental lamella becoming wider below than in worker. Gastric costulae very coarse, extending more than  $1/3$  the length of the basal tergite. This individual yellowish ferrugineous, probably not having achieved its full coloration. Forewing about 2.2 mm. in length, with only R + Sc, stigma and 2r distinct, and these without pigmentation; M + Cu and part of Cu 1, and also "basalis" indicated by feeble streaks.

*Gynotype* described from a winged female, one of several taken in a nest containing workers and males, August 7, 1948, University of Tennessee Farms at Knoxville (D. W. Pfitzer). Eight other female specimens from various parts of the range: TL 2.38-2.55, HL 0.58-0.61, WL 0.60-0.67, CI 67-71, MI 16-19. Southern females tended to follow the workers in being smaller in size. Color light to medium ferrugineous, the ocellar triangle usually slightly infuscated, or sometimes strongly blackened.

*Allotype male:* TL 2.18, HL 0.49, WL 0.70, CI 77. Full length of a mandible ca. 0.15 mm. Greatest diameter of compound eye about 0.20 mm.; distance from anterior border of compound eye to mandibular insertion ca. .05 mm. Eyes proportionately large, very convex. Mandibles much reduced, slender, their acute tips nearly or exactly meeting at full closure; apical and basal borders only very feebly differentiated by a gentle convexity. Notauli developed anterolaterally only; parapsidal furrows fine but distinct. Scutum and scutellum with a straight distinct median carinula; the fine punctulation of both surfaces arranged in longitudinal rows so as to form striae. Meso- and metapleurae smooth and shining over most of their surfaces, anepisternum posterior and katepisternum ventromedially with feeble, suppressed longitudinal striation. Dorsum of propodeum finely transversely striate. Propodeal teeth reduced to low obtuse angles trailing distinct infradental carinae. Petiolar node subglobose, a little broader than long; both petiolar and postpetiolar nodes smooth and shining above. Spongiform appendages reduced to fine, whitish cariniform and subcariniform vestiges. Anteroventral surface of gaster with a patch of long, fine, whitish reclinate hairs.

Hairs of head fairly numerous, but fine, short and inconspicuous, reclinate or sub-reclinate. Alitrunk, nodes and gastric dorsum with sparse fine reclinate hairs and a few short fine erect hairs. Apex of gaster, especially ventrally, with rather dense covering of short fine simple hairs. Head black, alitrunk blackish-brown; nodes and gaster castaneous; legs, antennae and mandibles ivory yellow. Forewing L 2.25 mm.; venation as in female.

Allotype taken from one of the original nests cited as *venatrix* by the Wessons, Pike Co., Ohio, date unknown, collected by the Wessons.

Six other males from the same colony as the allotype and from the same nest as the gynetype (see above) are rather variable in several respects. TL 2.06-2.31, CI 76-80. One of the Tennessee specimens has a faint anterior sulcus on the mesonotum, the head is deep brown in color, and the mesopleurae are quite distinctly longitudinally striate and opaque to subopaque. Propodeal teeth and carinae varying in development with the individual. In all details, including form of genitalia, this species seems similar to *pulchella* in the male caste.

*Material examined:* Holotype, a single worker [INHS], *type locality:* Herod, Illinois (T. Frison and H. Ross).

Numerous series and a few strays were examined from the following additional localities:

ALABAMA: Elrod, Tuscaloosa Co. (E. O. Wilson; B. D. Valentine); Chattanooga State Park, Houston Co. (B. D. Valentine); Mobile (W. S. Creighton).

FLORIDA: Welaka, Putnam Co. (A. Van Pelt).

ILLINOIS: Marshall, in *Andropogon* sod (Ross, Gloyd and Stannard); Alto Pass, Jan. 10, 1946 (H. Ross and B. Burks); Siloam Springs, Brown Co. (C. C. Hoff); Bell Smith Springs (M. Sanderson and L. Stannard); La Rue (Ross and Sanderson) and one or two other localities in the southern part of the state, all by personnel of the Illinois Natural History Survey.

LOUISIANA: In a water-oak bottom near Slidell (W. L. Brown).

NORTH CAROLINA: Williamston; Fayetteville (D. L. Wray).

OHIO: Adams, Lawrence, Pike and Scioto Counties, numerous collections by L. and R. Wesson, originally identified as *venatrix*. The types of *venatrix* [MCZ, USNM, etc.] came from Kitts Hill, southern Lawrence Co.

TENNESSEE: University Farm, Knoxville (D. W. Pfitzer).

This is one of the commonest North American species, and it will probably prove to be even more common as Berlese funnel collecting is extended. It should reach southern New Jersey in the pine barrens, although East Coast collections are few at present. For details of biology, the very full treatment of the Wessons (as *venatrix*) should be referred to. Full ecological data obtained since 1939 bear out these authors in considerable detail. *Talpa* feeds on collembolans in nature; characteristically damaged specimens of *Isotoma viridis* Bourlet and an indeterminate *Entomobrya* (determined by Mr. Kenneth Christianen) were found in one of the Alabama nests referred to above, sent by Mr. Valentine.

SMITHISTRUMA (SMITHISTRUMA) WRAYI Brown

Pl. I, fig. 9

*Smithistruma (Smithistruma) wrayi* Brown, 1950, Trans. Amer. Ent. Soc. 76:38-39, Pl. 3, fig. 5, worker.

*Holotype worker*: TL 2.02, HL 0.53, WL 0.50, CI 70, MI 17. Resembling small *talpa* specimens very closely, except in the pilosity, and possibly also in the gastric costulae, which extend clearly more than 1/3 the length of the basal tergite and appear longer and more distinct than in any of the *talpa* workers examined.

Free clypeal border with 4 inverted spoon-shaped hairs on each side, these broader than those of *talpa*, but not so broad as in *reflexa*, directed laterally and somewhat obliquely posteriorly. There are also about 4 very small indistinct hairs at the center of the anterior border, and these also seem to be directed away from the midline. Disc of clypeus granulose-punctulate and opaque, with rather abundant but inconspicuous and finely subspatulate hairs evenly distributed over surface and inclined sharply posteriorly. The hairs of the verticociput seem a bit heavier than those of *talpa*, but the difference in this respect is so slight as to require direct comparison against *talpa* specimens for its appreciation. Color medium ferrugineous, first gastric segment a bit darker and more brownish.

Holotype a unique [MCZ], collected by Dr. D. L. Wray by means of the Berlese funnel from leaf mould at Fayetteville, North Carolina. The species is named for the collector, whose zealous collecting has contributed much to the knowledge of the Nearctic dacetine fauna. The remarkable increase in records of dacetine and other minute, more or less cryptobiotic ants during the last ten years is due chiefly to the Berlese funnel collectors like Dr. Wray and the staff of the Illinois Natural History Survey. These biologists have demonstrated fully that many species of the microgenton remain unknown, even in the eastern United States.

*S. wrayi* is very distinct from *talpa* by virtue of the fewer, larger backswept hairs on the sides of the free clypeal border. The only species with which *wrayi* might be confused is *reflexa*, but the latter species can easily be distinguished by means of its broader head and distinctly wider clypeus. The clypeal disc of *reflexa* is impressed in the center and has no small hairs except close to the free border; the habitus of the two species is entirely different.

The new species is apparently a form of the *talpa* group paralleling pilosity developments in other groups.

SMITHISTRUMA (SMITHISTRUMA) FILITALPA Brown

Pl. I, fig. 8

*Smithistruma* (*Smithistruma*) *filitalpa* Brown, 1950, Trans. Amer. Ent. Soc. 76:39-40, Pl. 3, fig. 5, worker.

*Holotype worker*: TL 2.06, HL 0.54, WL 0.52, CI 66, MI 17. Head, clypeus and mandibles like those of very slender *talpa* specimens in general form. Clypeus extremely slightly broader than long, opaque, differing from that of *talpa* in its pilosity, which is slightly longer and more abundant, the individual hairs soft, weak and filiform, not sensibly enlarged at their apices and weakly curved anteromedially. Hair on the center of disc evenly distributed, weakly arched-subreclinate, nearly or quite as long as those on the free border. Hairs on the upper dorsum of the head slightly stouter, more nearly clavate or spatulate and more erect than in *talpa*. Lateral borders of occipital lobes each with two long weak flagelliform hairs.

Pronotum in profile shallowly but distinctly concave, meeting the mesonotum through an obtusely rounded angle. Pronotum very indistinctly longitudinally carinate in the middle, the mesonotum a bit more distinctly so. The feebly depressed portion of the pronotum with sculpture more or less effaced, rather smooth and distinctly shining, as in also the case with the dorsum of the petiolar node. Basal costulae of gaster shorter than is usual in *talpa*, extending 1/4 or less of the length of the tergite bearing them. Color light ferrugineous.

Holotype a unique [USNM]. The label with the specimen stated only that it came from Pike County, Arkansas, collected by W. F. Turner. As with *S. wrayi*, this species is a pilosity variant on the *talpa* pattern, although it does display a few additional sculptural differences that seem at present to be significant. Although these two *talpa* group species are described from single specimens, I do not believe that they can be considered mere extreme variants of *talpa* itself, for I have examined enough *talpa* from enough localities to satisfy myself that this common species varies within very strict limits as regards pilosity. I do not think that these are abnormal specimens, either, since I have seen only one proven case of an abnormal specimen in the whole tribe. While *wrayi* and



*filitalpa* may be very rare species, it is more probable that they have just not been looked for in the right places. It is suggested that both are possibly grass-sod dwellers best collected with the Berlese funnel.

*Filitalpa* can easily be separated from the superficially similar species *pilinasis* and *laevinasis* by means of its depressed, clearly diastemate mandibles and its opaque clypeus, as well as by its *talpa*-like form.

SMITHISTRUMA (SMITHISTRUMA) CREIGHTONI (M. R. Smith)

Pl. I, fig. 1

*Strumigenys* (*Cephaloxys*) *creightoni* M. R. Smith, 1931, Ann. Ent. Soc. Amer. 24:705-706, Pl. 4, fig. 16, worker. *Strumigenys* (*Cephaloxys*) *creightoni* L. and R. Wesson, 1939, Psyche 46:110, worker, in key. *Strumigenys* (*Trichoscapa*) *creightoni* M. R. Smith, 1947, Amer. Midl. Nat. 37:587.

*Worker*: TL 2.17-2.44, HL 0.57-0.61, WL 0.53-0.61, CI 65-67, MI 17-20. Measurements taken from 12 workers from the type colony and one somewhat nanitic worker from the District of Columbia, the smallest measurements given representing the latter specimen.

Head and mandibles as in *talpa*; M. R. Smith gives a good figure of this ant in his 1931 paper. The anterior clypeal border is more nearly transverse in the center than is that of *talpa*; clypeus extremely slightly or not broader than long and not more than half as wide as the width of the head across the occipital lobes. Mandibles with an acutely pointed basal tooth nearly as long as the length of the diastema following it, dentition otherwise as in *talpa*.

Alitrunk feebly depressed; promesonotum gently convex in profile, outline from anterior mesonotum to propodeal teeth straight and virtually uninterrupted, due to the absence or very feeble depression of the metanotal groove. Anterior pronotal margin poorly marked and humeral angles not developed; median pronotal carinula obsolete, but present as a feeble vestige on the mesonotum. Propodeal teeth lamelliform, laterally compressed and acute, continued below by very narrow concave lamellae which are not or only very feebly angularly produced at the ventral extremities. Petiolar node slightly higher, its anterior face sloping a bit more steeply, than in either *talpa* or *bunki*.

Pilosity distinctive. Dorsum of head (and more sparingly the alitrunk) covered with abundant, moderate-sized but rather conspicuous inverted spoon-shaped hairs, sharply bent anteriorly so as to appear nearly subappressed. Hairs on clypeus small, abundant, spatulate and nearly or quite appressed, directed anteriorly. Hairs fringing free clypeal border on each side of the middle 9-11, those in the middle and farthest back on the lateral borders small and narrow, but the 4 or 5 hairs along the rounded anterolateral portions of the border larger and distinctly broadened into narrowly oval blades with subacute apices, all curved medially. The hairs of this clypeal fringe are more numerous and crowded and also slightly smaller than those of *bunki*. Hairs on anterior scape border shorter and broader than those of *bunki*, 2-5 usually turned toward base of scape. No specialized long erect hairs on occipital region or on alitrunk; only the humeral hairs, one on each side, larger and very feebly differentiated from the other spoon-shaped hairs accompanying them, but even these reclinate or nearly so. Dorsal surfaces of nodes and gaster with long, fine flagellate hairs, much as in *talpa*.

Basal gastric costulae 15-21 in number, extending 1/3 or a little more the length of the basal tergite. Color light to medium ferrugineous.

*Gynotype female*, dealate: TL 2.64, HL 0.64, WL 0.68, CI 70, MI 15. Differing from the worker in the usual full sexual attributes. Mesonotum with a few feeble longitudinal rugulae and covered with rather abundant but well-spaced hairs like those of the head; posteriorly with two short incurved subflagellate hairs. Summit of petiolar node angular in profile, seen from above, the anterior dorsal nodal margin (line of summit) transverse and feebly concave, the lateral corners of the summit prominent and subrectangular. Color as in worker.

*Gynotype* one of two dealate females taken by Dr. Creighton from the type nest (see below); deposited in MCZ. Male unknown.

*Material examined*: A cotype worker in USNM; the specimen placed in the type tray is designated as *lectotype*, fixation present. About 25 additional workers from the type nest, now in the collections of Dr. W. S. Creighton and the MCZ, were also examined. *Type locality*: Spring Hill, Mobile, Alabama (W. S. Creighton). Also examined

was a single nanitic worker taken at Hamilton Hill, District of Columbia by H. S. Barber. There are no direct observations on the biology known to me. Other identifications of this ant are extremely questionable, since various specialists have confused both *bunki* and *rostrata* with it in the past. All records have been reviewed by either myself or by Dr. M. R. Smith, and neither of us has been able to verify a single additional locality. *Creightoni* seems to be southern in its range, and though the very scanty material is not to be accepted as indicating any final opinion, the nanism of the District of Columbia worker may show that the species becomes depauperate near its northern limit as some other species seem to do in reverse.

As stated above, *creightoni* has been confused with both *rostrata* and *bunki* new species. The differences between this species and *rostrata* are so many and so clear that it does not seem worth while to point them out here, but it must be admitted that the resemblance between *creightoni* and *bunki* is extremely close. I have outlined several differences under *bunki* (see below), and in case of doubt, the number of principal teeth in the mandibular apical series can always be checked for certain placement. If it be remembered that *creightoni* has the general features of the *talpa* group, identification will be made considerably easier.

#### ROSTRATA GROUP

This is a very widespread group, with unquestionable representatives in the Eastern United States, California and in temperate eastern Asia. Several species of the Ethiopian and Neotropical Regions might also be placed here, but these exotic species are mostly "aberrant" in some respect and are more conveniently placed in other groups for the present.

Species here considered of the group are *rostrata* and *bunki* from the eastern part of North America and *californica* from the West Coast. The latter is very possibly introduced from the Orient. The two Japanese species *incerta* Brown and *rostrataeformis* Brown are described in Part I of this revision (see below under Palearctic species).

*Rostrata* and allies are characterized by the laterally protruding occipital lobes and the straight, parallel preocular laminae, which give the head a rather blocky, not at all cuneiform appearance seen in full face view. The clypeus is definitely broader than long, its anterior border transverse and with a tendency towards a feeble concavity or emargination of the anterior central portion. As in other species of *Smithistruma*, the hairs in the center of the anterior border are shorter than those immediately on each side on the "antero-lateral corners." In the *rostrata* group, this situation is somewhat more exaggerated due to the more enlarged hairs at the sides of the anterior clypeal border and the fact that the hairs mesad of these become rapidly shorter, the apices of all the hairs on the anterior border outlining a semicircle opening anteriorly. Because of this arrangement, the emargination of the anterior clypeal border is heightened by illusion; sometimes the border will appear concave when in point of fact it is perfectly straight. Creighton's method of applying some fluid with such a refractive index as to cause the hairs to become invisible should be used in gauging the actual shape of the anterior clypeal border in all groups where illusion is suspected.

*Rostrata* group mandibles are characteristically adiaestemate, or, in the case of *bunki*, with a very small, insignificant diastema shorter than the length of the acute basal lamella. The principal teeth are 5 in number and often rather coarse; in *rostrata* and other species in which the dentition is well known, teeth 6 and 7 are nearly as large and as well developed as the preceding teeth of

the principal series, and are logically included with the latter. Mandibular shafts usually moderately broad and depressed.

In pilosity, the group is not especially distinctive; the majority of the hairs on the head and alitrunk are usually short-spatulate or spoon-shaped and mostly reclinate. Specialized erect hairs may or may not be present on head and alitrunk, according to species; fine erect hairs occur on the postpetiole and gaster. Other characters of body form, sculpture, etc. much as in the other Nearctic groups.

The female is similar to the worker except in the usual characters of full sexuality. The male is known for only one species, *rostrata*, and this is distinctive by virtue of its mandibles, which are strongly serially toothed, approaching the worker in this respect. The volsella is somewhat different from those of some other Nearctic species in having a slender, non-constricted digitus with acute or subacute apex.

Except for *rostrata* and *bunki*, records are so few that little can be said about nest sites, feeding or other biological characteristics. *Rostrata* is very common and nests either in rotten logs or in the soil. It sometimes chooses distinctly dry and exposed situations, and feeds on springtails. *Bunki* seems to prefer to nest in the soil or soil cover, and is apparently limited in distribution to the warmer states of the southeastern United States. *Rostrataeformis* of Japan will nest in rotten stumps, but may not be restricted to such an environment.

The species of this group are distinguished from one another by differences in total body size, shape and proportions of head and mandibles, mandibular dentition, pilosity, etc.

The new species, *bunki*, is interesting in that it appears to form a link between the *rostrata* group and *pulchella*. *Rostrata* also shows signs of relationships to the *schulzi* group through species like *orchibia*, to the *emarginata* group through *incerta*, to certain species in the *alberti* group through *conspersa*, etc. The relation to *conspersa* seems, on a strictly morphological basis, to be fairly close, and I have formerly considered *conspersa* to be a *rostrata* group member. The connections of the group are seemingly so wide that I have considered *rostrata* and allies as being close to the primitive line of *Smithistruma*. It must be pointed out, however, that the resemblances to other groups are largely those of habitus, and that a great deal of detailed morphological investigation remains to be accomplished before many of these relationships can be fully sanctioned. Furthermore, the distribution of the group in eastern Asia and the eastern Nearctic seems to point to a fairly recent passage across the Northern Filter Bridge, while species like *alberti* would seem to have been in the New World for a longer time. There can be no doubt of the very close relationship between the Japanese forms and *rostrata*. The small genus *Miccostruma* of the Ethiopian Region seems to have been derived from a *rostrata*-like ancestor.

SMITHISTRUMA (SMITHISTRUMA) BUNKI Brown

Pl. I, figs. 6, 10

*Smithistruma (Smithistruma) bunki* Brown, 1950, Trans. Amer. Ent. Soc. 76:41, 42, Pl. 3, figs. 2, 3, worker.

*Holotype worker*: TL 2.24, HL 0.58, WL 0.55, CI 66, MI 18. Head with bulg-

ing occipital lobes and parallel, very nearly straight preocular laminae; clypeus about 1.2 times as broad as long and considerably more than half as wide as the width across the occipital lobes. The sides of the clypeus gently convex and converging; anterior border broadly transverse and straight; in some views and under liquid, the anterior border showing signs of a very feeble, almost imperceptible concavity. Free clypeal border with a single margin, the sides with moderately prominent scalloping due to the small, blunt piligerous tubercles.

Mandibles each with a basal lamella shaped much as in *creightoni*, the base of this lamella broad and the apex attenuated and acute. Diastema following very small, much shorter than the length of the basal lamella; apical series with 5 principal teeth, of which no. 3 is the largest and nos. 2 and 4 the shortest. Nos. 6 and 7 small; denticles and apical tooth as usual.

Eyes small, with only 13-16 facets. Antennal scape obtusely bent near base, somewhat flattened, thickest at about the proximal third of its length, with a tuberculate angle at the bend anteriorly. Alitrunk much as in *creightoni*; remainder of body as in the majority of Nearctic species. Propodeal teeth short, compressed, acute; infradental lamellae continuing them directly below, decidedly broader than in *creightoni*, not strongly concave, ending ventrally in a convex broadening.

Pilosity approximately intermediate between that of *rostrata* and *creightoni*, most like that of the later species, but the hairs fewer, spaced at greater intervals and slightly larger. Hairs on free clypeal border fewer (7 or 8 on each side of the center), larger, more broadly spatulate and spaced a bit farther apart than in *creightoni*. Small appressed hairs on the almost flat disc of the clypeus forming obscure lines in a radiating pattern. Of the hairs fringing the free border, those at the anterolateral angles are largest; all the hairs of the fringe are curved anteromedially. Hairs on the scape borders linearspatulate, a bit longer than those of *creightoni*, and not so broad; the longest hair, situated at the anterior tuberculate angle of the bend, about as long as the breadth of the scape itself at that point and at least half again as long as the next hair distal to it. Anterior scape hairs 1 and 2 curved laterally; 3 (the largest), 4, 5, 6 curved toward the base of the scape; the last two or so hairs very small, directed apically. In general, the cephalic pilosity numbers about 2/3 to 3/4 as many individual hairs as in *creightoni*. Alitrunk dorsum with sparsely distributed, subdeclinate, narrowly squamose hairs; each humerus with a stiff outstanding simple hair (this varies from feebly clavate to flagellate in the paratypes) which is about twice the length of the other hairs on the pronotum. Hairs of nodes and gastric dorsum like those of *creightoni*, but slightly shorter and fewer. Color light ferrugineous.

Holotype [USNM] selected from a small series of workers taken in a pine woods near Landon, Mississippi (A. C. Cole, Jr.).

Paratype workers: TL 1.91-2.14, HL 0.55-0.59, CI 64-69, MI 16-20. Clypeus varying from 1.15 to 1.25 times as broad as long. 26 workers, divided among representatives of five separate nests, including the type nest series and other collections as follows: Slidell, Louisiana, 3 workers taken foraging in the open over moss at the base of a large live oak growing in a luxuriant water oak bottom along the Bayou Liberty (W. L. Brown). Savannah, Georgia, two small nest series, one taken from a hickory nut lying on the ground and the other (containing the gynetype) in a small cavity in the soil, January, 1949 (H. T. Vanderford). Welaka, Putnam Co., Florida, a single worker (A. Van Pelt). Paratypes placed in USNM, MCZ, ANS, Consani Coll., and the collections of Dr. A. C. Cole, Jr., University of Tennessee, and Mr. Arnold Van Pelt, University of Florida Conservation Preserve, Welaka, Florida. The workers agree rather well in size and general form of body. The long paired hairs of the humeri very variable from series to series, not developed at all in some of the Georgia specimens. Infradental lamellae varying slightly in degree of concavity, but never becoming so narrow or deeply excised as in *creightoni*. Hairs fringing free clypeal margin a bit shorter in the Florida specimen than in the other paratype series, but even here the hairs are closer to those of the holotype than to those of *creightoni*. Color rather constant, light to medium ferrugineous. Dentition appearing highly constant in 6 workers dissected from Louisiana, Mississippi and Georgia.

Gynetype female, dealate: TL 2.45, HL 0.60, WL 0.61, CI 69, MI 19. Differing from the worker in much the same way *creightoni* differs from its worker. Humeri rounded, each with a long crooked flagellate hair. Mesonotal surface evenly and densely

punctulate, without traces of longitudinal carinula or rugulation. Petiolar node as in the *creightoni* female, but seen in side view a little lower and not so angular above. Basal costulae of gaster extending nearly half the length of the basal tergite. Color as in workers or very slightly darker.

Gynotype taken from a colony nesting in the soil at Savannah, Georgia, Jan. 15, 1949 (H. T. Vanderford; mentioned under paratypes above) deposited with the holotype. Male unknown.

From the present records, this species seems to be restricted to the extreme southeastern part of the United States. It is apparently a soil and soil cover nester.

This form resembles *creightoni* so closely in outward characters that I was originally very doubtful of its distinctness. The two species are separable on habitus, since *creightoni* has the *talpa* type of head and mandibles, while the head and mandibles of *bunki* are superficially more as in *rostrata*. The larger, fewer fringing hairs of the free clypeal border are characteristic of *bunki*, as is the much smaller, less distinct diastema of the mandibles. In cases of doubt, a mandible should be removed and mounted for examination at higher magnifications; it is believed that the difference in dentition between the two species is constant and highly reliable, although when more specimens of *creightoni* become available, the variability of the dentition in various series should be checked.

Despite the very close resemblance between the two species, it appears that the points of similarity are parallel developments in the representatives of two different stocks. *Creightoni* is of the *talpa* group, while *bunki* seems more closely related to *rostrata* and may possibly be considered intermediate between *rostrata* and *pulchella*.

*S. bunki* is named for the late Bunk Johnson, of New Iberia, Louisiana.

#### SMITHISTRUMA (SMITHISTRUMA) ROSTRATA (Emery)

Text-figs. 2, 4; Pl. II, fig. 26; Pl. III, figs. 28, 32

*Strumigenys rostrata* Emery, 1895, Zool. Jahrb. Syst. 8:326, 329, Pl. 8, figs. 23, 23a, 24, worker, female, male. *Strumigenys* (*Cephaloxys*) *rostrata* Emery, Gen. Ins. Fasc. 174:325, Pl. 7, fig. 6, worker. M. R. Smith, 1931, Ann. Ent. Soc. Amer. 24:704-705, Pl. 2, fig. 8, worker. L. and R. Wesson, 1939, Psyche 46:99-100, biology. *Strumigenys* (*Trichoscapa*) *rostrata* M. R. Smith, 1943, Amer. Midl. Nat. 30:307; 1947, Amer. Midl. Nat. 37:587, Pl. 14, fig. 54, worker.

*Worker.* TL 2.40-2.75 (2.50-2.65), HL 0.61-0.72, WL 0.61-0.69, CI 67 (rarely 66 or 68), MI 19-20. The total length given by Emery ("2-2½ mm.") and followed uncritically by Smith cannot be accepted. I have examined more than 70 series and additional strays of this species, including nest groups which seemed to be incipient, and the smallest worker found measured 2.42 mm.; out of over 400 workers placed under the ocular grid, only 3 individuals were less than 2.50 mm. long. A point is made of this correction because the total length is an important character for the identification of *rostrata*.

*Rostrata* has been very well described in the past literature and figured better than any other dacetine ant. Two of Smith's figures are used again here; the side view of the worker (text-fig. 2) is very good in all details, except that it fails to show the transverse row of 4 obliquely erect hairs usually present on the posterior occiput and the two pairs of stiff, erect tapered hairs, one pair (L 0.10-0.12) on the humeri and the other on the sides of the anterior mesonotum (L 0.14-0.16). The full face view (text-fig. 4), taken from the 1931 review, has overinflated antennae and shows a few very minor errors of detail in the mandibular dentition and posterior cephalic pilosity. Except for these details, the figures show very nicely what the species is like.

In all the specimens I have seen, the anterior clypeal border is feebly emarginate in the center. Dr. Smith denies (in litt.) that all specimens show such emargination, but I am of the opinion that all specimens viewed from a perpendicularly dorsal position will show at least feeble traces of the character in question.

The mandibles are quite distinctive in shape and dentition (see Pl. II, fig. 26), the blades depressed and fairly broad, the apices only feebly deflected downward. The rather coarse teeth present an unbroken series from anterior clypeal border to near the apices when the mandibles are closed, imparting to this insect a rather ferocious appearance.

The pilosity of the gaster is not usually flagelliform, since the individual hairs are often truncate or even feebly subclavate at their apices. A transverse row of four such

slender hairs is found anteriorly inclined along the longitudinally costulate anterior portion of the first gastric tergite.

Color dark ferrugineous, gaster darker; occasional specimens very dark, almost black; teneral specimens much lighter. Dorsum of head often lightly infuscated.

*Female:* 6 dealate specimens from Alabama, Illinois, Pennsylvania, Ohio, Tennessee and Virginia; TL 2.82-3.01, HL 0.68-0.73, WL 0.72-0.77, CI 67-69, MI 19-21. Eyes large and protruding. Tuberculation of free clypeal border and of dorsolateral occipital borders more conspicuous than in the worker. Scutum finely and rather indistinctly striate over its dense punctulation. Surface of scutellum convex, raised above the level of the scutal dorsum. Mesopleurae (katepisternum and lower half of anepisternum) and alitruncal pleurae posterior to this smooth and shining. Petiolar peduncle at least as long as its node. Basal gastric costulae coarse, subfiliform, extending about  $2/5$  the length of the first gastric tergite. Color as in workers or a bit darker.

*Male:* Described by Emery, who gave the total length as " $2\frac{1}{2}$  mm." Two specimens from Ohio and Tennessee measure about 2.65 and 2.70 mm. respectively. Still other specimens from both of these states were dissected and were found (in 4 examples) to have genital volsellae as in fig. 28 and mandibles as in fig. 32. It may be noted that Emery's figure of the male mandible shows fewer teeth than in my figure; while this may show normal variation in the dentition, I am inclined to believe that Emery's mandible was drawn at an angle which did not reveal the full dentition. Mandibles which turned in my balsam mounts gave the illusion that certain teeth had disappeared. No other male *Smithistruma* known to me has anything like as full dentition as portrayed even in Emery's figure. Anterior mesonotum with a short, weak longitudinal furrow; notauli quite distinct except posteromedially at the point where they would normally coalesce. Mesonotum evenly and densely punctulate, without striation. Sculpture of sides of alitrunk much as in the female. Vestiges of propodeal teeth forming low obtuse angles; infradental lamellae obsolete except for a tiny angular ventral vestige on each side of the base of the declivity. Petiolar node long, evenly rounded in profile, longer than its peduncle, but broader than long seen from above. Both nodes smooth and highly shining; spongiform appendages vestigial, thinly lamelliform, but a bit better developed than are those of *pulchella*. Gaster without basal costulae, entirely smooth and shining. Color deep brownish-black; nodes and gaster deep castaneous; mandibles, antennae, legs and genitalia sordid yellowish-brown. Volsellae larger than those of the *pulchella*, clypeata, and *talpa* groups, shaped much as in *S. (W.) pergandei*. Forewing length 2.2-2.3 mm.; venation as in *pulchella*.

The types of all three castes are in the Emery Collection and presumably also in some other European collections. Various North American collections contain specimens collected by Pergande and labelled as types. These specimens are not true types, but may be nidotypes. *Type locality:* Washington, D. C. (T. Pergande).

More specimens of *rostrata* have been examined during the course of the present work than of any other single species of *Smithistruma*. Many localities have been published by other authors, and there seems to be no point to listing the 60-odd collections from which I have seen specimens. There are numerous collections from the southern parts of New Jersey, Pennsylvania, Ohio, Indiana and Illinois south to the Gulf of Mexico, including low and medium altitudes in the southern Appalachians. West of the Mississippi, *rostrata* has been taken in northern Missouri and in Louisiana, so that it undoubtedly occurs in Arkansas. The record from California given in Smith's paper of 1931 is based on two females determined as *rostrata* by Wheeler; these two specimens are made the types of *S. californica*.

The biology has been summed up pretty well by the Wessons in their paper on the species from southern Ohio (loc. cit.); their statements seem to apply to this common species wherever it is found. I have mentioned elsewhere (in press) some observations on the prey selectivity shown by a *rostrata* colony I have kept in captivity for a year and a half. These ants preferred the collembolan families Entomobryidae and Isotomidae as prey, and shunned genera like *Onychiurus* and *Anurida* offered them. Some of the colonies sent me contained over 200 workers and 3 to 5 queens.

#### SMITHISTRUMA (SMITHISTRUMA) CALIFORNICA Brown

*Smithistruma (Smithistruma) californica* Brown, 1950, Trans. Amer. Ent. Soc. 76:40-41, female.



*Holotype female*: TL 2.41, HL 0.64, CI 67, MI 17. Head intermediate in shape between *rostrata* and *bunki*. Posterior excision shallow, verticociput moderately convex in profile to just behind clypeus. Preocular laminae subparallel, weakly convex. Clypeus about 1.10 times as broad as long; sides rounded and rather sharply converging; anterior border transverse, feebly emarginate in the center. Mandibles as in *rostrata*, with similar dentition, but slightly shorter. Distance across the bases of the fully closed mandibles, from external border to external border, about 0.14 mm. Length of antennal scape about 0.36 mm., bent at an angle of  $35^\circ$  or  $40^\circ$  at about the basal third and broadest at the bend, which is concave posteriorly and subangulate anteriorly. Apical funicular segment longer than the preceding four segments taken together; segment IV about as long as I and longer than II and III taken together.

Alitrunk generally as in the female of *rostrata*, but less robust. Humeral angles blunt, but more distinct than in *rostrata* or *incerta*. Infradental lamellae of propodeum convexly expanded below the short, compressed teeth. Petiole, postpetiole and gaster like those of *rostrata* allowing for smaller size, with similar spongiform appendages.

Sculpture much as in the female of *rostrata*, although the dorsum of the petiole in both the holotype and paratype seems rather smooth and shining.

Pilosity most similar to that of *rostrata* and relatives, but differing in detail. Clypeal border on each side of the midline with about 11 short, anteromedially curved spatulate hairs, shorter and broader than those of *rostrata*, but not so broad as those of *bunki*. The largest hairs, on the anterolateral "angles," are approximately as long as the third funicular segment, while those higher up on the sides of the clypeus are only about half as long and are much narrower. Hairs on surface of clypeal disc short, subappressed, varying in degree of squamosity and rather small, so that the opaque clypeal surface is clearly visible. Hairs on upper dorsum of head rather small and inconspicuous in dorsal view, fairly numerous, apices spoon-shaped and bent toward the midline, becoming longer and narrower posteriorly. The extreme occipital region with one or two transverse rows of a few longer, erect, weakly clavate hairs. Hairs on anterior border of scape moderately elongate, those nearest the bend longest and with distinctly broadened apices. Alitrunk dorsum with a very few short simple hairs among more numerous short, suberect and suberect, curved linear-spatulate hairs. Nodes clothed similarly to the alitrunk, but with a few fine flagelliform hairs. Humeri also each with a long weak flagelliform hair. Gaster with a sparse growth of very fine flagellate hairs, erect and distinctly more numerous than those of the worker or female *rostrata*.

Color ferruginous yellow; tip of gaster slightly darkened.

*Holotype female* [MCZ] taken by C. F. Baker at Claremont, California; without further data. This and the accompanying paratype bear remains of wings and must have been taken during nuptial flight. I regret to say that I have broken a number of the mandibular teeth in the holotype while seeking to investigate the details of the dentition. The bases of the broken teeth, however, will show the positions and the lack of a diastema very nicely.

*Paratype female* [MCZ], with same data as for holotype. Head missing. WL 0.82. A single hind wing is still attached.

This is a very puzzling species, and represents the only certain record for *Smithistruma* from west of the Great Plains in North America. Since the type locality is largely given to intensive agriculture and was formerly semidesert in type, it is difficult to believe that any *Smithistruma* is native there. Baker, the original collector, travelled in the Orient, and it is not unthinkable that this collection may be grossly mislabelled. Another possibility is that the species has become established as an immigrant from East Asia. Certainly, the species bears the strongest resemblance to the two *rostrata* group forms I have described from Japan. The clypeal pilosity is quite distinct from that of the closest Nearctic form, *rostrata*, and the size is much smaller. These two females are different from the known specimens of *incerta* and *rostrataeformis* of Japan in a number of pilosity characters and in details of proportions of head, mandibles and clypeus best followed by comparing the descriptions. Because of the possible Oriental origin of the *californica* specimens, I have taken care to satisfy myself of their distinctness from the known species of that fauna. The possibility that *californica* really is a native ant should be investigated, especially since Cole has claimed to have found a specimen (subsequently lost) answering to the *Smithistruma* pattern in northern California. The discovery of the worker caste will probably aid in determining more closely the relationships of *californica*.



## NEARCTIC SPECIES NOT ATTACHED TO ANY PARTICULAR GROUP

## SMITHISTRUMA (SMITHISTRUMA) OHIOENSIS (Kennedy and Schramm)

Pl. I, fig. 4; Pl. II, fig. 19; Pl. III, fig. 30

*Strumigenys ohioensis* Kennedy and Schramm, 1933, Ann. Ent. Soc. Amer. 26: 98-99, figs. 1, 2, worker. *Strumigenys* (*Cephaloxys*) *manni* L. and R. Wesson, 1939, Psyche 46:97-99, Pl. 3, fig. 3, worker, biology. (new syn.) *Strumigenys* (*Cephaloxys*) *ohioensis* L. and R. Wesson, 1939, Psyche 46:109, worker, in key. *Strumigenys* (*Trichoscapa*) *ohioensis* M. R. Smith, 1947, Amer. Midl. Nat. 37:587; *S. (T.) manni* also listed here.

*Worker*: TL 2.24-2.52, HL 0.59-0.65, WL 0.58-0.62, CI 68-72 (69-70), MI 21-26 (23). Measurements from 34 workers from all localities listed below, including the *ohioensis* holotype and types of *manni* and observed size extremes from among 275 workers examined.

Head very superficially similar to the *clypeata* form at first glance, but the occipital lobes more broadly expanded laterally and the preocular laminae only weakly convergent or subparallel. Clypeus varying from extremely slightly broader than long to as long as broad or (very rarely) slightly longer than broad; lateral margins converging anteriorly and forming a more or less continuous outline with the preocular laminae and the external borders of the closed mandibles. Anterior clypeal border with a very thin, narrow, rounded lamelliform border, this border weakly depressed and difficult to see in specimens with full pilosity unless a drop of liquid be added for the purpose of rendering the hairs transparent. When dry, the clypeus appears somewhat truncate anteriorly, as shown in the figure given by the Wessons. Clypeal surface punctulate-granulose and definitely opaque, with a minute tubercle bearing each clypeal hair. The clypeal hairs abundant and evenly distributed over the discal surface, but very fine, those in the center erect and very short, those on the free border longer,  $\frac{1}{6}$  to  $\frac{1}{4}$  as long as the greatest width of the clypeus, those on the sides curved away from the midline and with the apical parts curved posteriorly in a very characteristic J-shaped (or S-shaped) hook. The clypeal hairs are truncate apically, and at magnifications of  $140\times$  do not appear to be any broader at their apices than at their midlengths.

Mandibles large and strong, only moderately convex dorsally; basal lamella triangular, with a broad base and an acute apex, but less acute than in any other Nearctic species and considerably less acute than as shown in Kennedy and Schramm's figure. The lamella rests just at the anterior clypeal border when the mandibles are fully closed. Mandibular diastema very short and indistinct, even as seen in the dissected mandible, followed by a series of strong, sharp teeth; five principal teeth, the third longest.

Pilosity of upper dorsum of head, scapes and dorsum of alitrunk fairly abundant, very fine and moderately long, extremely feebly or not at all enlarged apically and arched toward the midline, more or less erect on the alitrunk, on the scapes directed toward the scape apex. A long flagellate hair is usually present on each humeral angle.

Alitrunk rather evenly convex in profile; some specimens with a feebly impressed metanotal groove. Propodeal teeth rather short but acute, directed slightly dorsad, with the very narrow, concavely arcuate infradental lamellae not widened below. Petiole with a long peduncle; node small and with a short anterior face rising at a rather steep angle. Petiole, postpetiole and gaster with scattered long simple hairs, arched posteriorly on the nodes; crookedly flagelliform, more or less erect hairs on the anterior gastric dorsum; hairs on posterior gaster long, fine, straighter and more erect, some truncate or with feeble apical enlargement.

Color medium to dark ferrugineous, the gaster usually darker and sometimes nearly black. Vertex usually infuscated.

*Gynotype female*, dealate: TL 2.76, HL 0.64, WL 0.68, CI 70, MI 23. Differing from the worker in the usual ways. Petiolar node rather slight, its summit twice as broad as long and shallowly concave viewed from the rear. Median longitudinal carinula of the mesonotum fine but distinct, flanked by some indistinct longitudinal rugulae. Mesonotum covered with abundant, fine posteriorly curved hairs. Basal gastric costulae distinct, with fine crowded intercalary costulae or striae between, extending about  $\frac{1}{3}$  the length of gastric tergite I. Ferrugineous; mesonotum and ocellar area infuscated. *Gynotype* [MCZ] taken singly in Berlese funnel material from leaf mould, edge of Lake Johnson at Raleigh, North Carolina, Jan. 9, 1949 (D. L. Wray). Three other females from

Illinois and Louisiana are slightly smaller: TL 2.68-2.71, HL 0.63, CI 72-74, MI 21-22.

*Allotype male*: TL 2.30, HL 0.48, WL 0.72, CI 80. Greatest diameter of eye 0.17-0.18 mm.; full length of mandible 0.18 mm. Mandibles with acute apices meeting at full closure; apical borders concave, each separated from its basal border by a prominent, broadly subdentiform angle. Mesonotum with notauli and anteromedian furrow very nearly obsolete; parapsidal furrows only moderately distinct. Scutal punctulae arranged more or less in longitudinal rows posteriorly, but not forming striation. Propodeal lamellae reduced to very fine carinae, no teeth or angles above, so that the propodeal profile is evenly rounded seen from the side. Ground pilosity of head and alitrunk long, fine, reclinate as in *clypeata*, without extra-long flagellate hairs on the lateral occipital borders; long flagelliform hairs confined to one on each humerus. Otherwise as in the same sex of *pulchella* and *talpa*, but the color generally darker, although the head is definitely black. Forewing as in *talpa*, about 2.2 mm. long; venation as in *talpa*, but the stigma and 2r very lightly pigmented and somewhat indistinct. The allotype and two closely similar males were taken from a nest under a very small stick lying on the ground, Sept. 9, 1947, on the University of Tennessee Farms, Knoxville, Tennessee (D. W. Pfitzer). The allotype will be placed in the MCZ and the alloparatypes in the University of Tennessee Collection.

*Material examined*: Holotype [MCZ] taken in a partially decayed oak rail embedded in the soil of a densely wooded area bordering a ravine at Tupper's Plains, Meigs Co., Ohio (M. M. Schramm). A single paratype taken with the holotype was not seen; this is deposited in the collection of Dr. C. H. Kennedy at Ohio State University, Columbus, Ohio.

ALABAMA: Bryce Lake, Tuscaloosa Co., leaf litter in deep shade (B. D. Valentine).

ARKANSAS: Washington Co. (M. W. Sanderson).

ILLINOIS: Antioch, Lake Co., from sphagnum moss in tamarack bog; La Rue; Astoria (H. H. Ross and M. W. Sanderson); Lincoln (T. H. Frison); Effingham, forest debris (Smith and Stannard); Giant City State Park (Sanderson and Stannard). All collections by personnel of the Illinois State Natural History Survey.

LOUISIANA: Harahan (F. G. Werner).

NORTH CAROLINA: Fayetteville; Yanceyville; Raleigh; all collections from leaf mould Berlese funnel samples (D. L. Wray).

OHIO: Pike Co. near Sinking Spring, humus in cedar grove (L. and R. Wesson). Types of *manni*; deposited in MCZ, USNM, etc.

TENNESSEE: More than one collection from the University of Tennessee Farms at Knoxville from nests under or in small pieces of wood lying on the soil surface (D. W. Pfitzer, J. W. Jones, Jr.).

VIRGINIA: Falls Church (Nathan Banks).

In all probability, this species will be found to reach southern New Jersey and Pennsylvania in the northeastern part of its range. All the records show that it is definitely a dweller in the soil cover and upper soil layers, often utilizing such shelters as are afforded by small chips and twigs lying on, or wood partly buried in, the soil. There are no records known from logs or stumps projecting well above the soil surface, which probably accounts for the fact that this very common species remained undescribed until 1933. The sphagnum bog record from extreme northeastern Illinois is very puzzling and unusual, especially since this species seems to prefer a rather mild climate judging from the rest of the distributional data.

The Wessons described *manni* without seeing an *ohioensis* type, but after referring to the Kennedy and Schramm description and figures. Unfortunately, this original *ohioensis* diagnosis is misleading in its characterization of the most important features, partly due to the fact that at least the holotype specimen does not have quite the full clypeal pilosity, and partly because the lengths and shapes of the remaining hairs were misjudged both in the original description and in the figures. Furthermore, as is noted above, the shape of the basal lamella was misinterpreted. As crude as it is, the figure given by the Wessons for *manni* seems to me to capture the general habitus of the average *ohioensis* worker head seen full face much better than does Kennedy's drawing from the same position.

Dr. L. G. Wesson has seen the *ohioensis* holotype in comparison with types of *manni*, and he agrees that the synonymy is in order. The holotype happens to be a somewhat nanitic worker, but it matches perfectly the smaller workers of other series.

I do not believe that *ohioensis* is at all closely related to any species of the *clypeata*

group, since very many characters in the female sexes and in the male differ strongly. The true relationships of this species remain obscure, although it is certainly of the same stock as the rest of the Nearctic species. The peculiar J-shaped pilosity of the lateral clypeal borders and the large, weakly diastemate mandibles will serve as distinguishing characteristics for the worker.

SMITHISTRUMA (SMITHISTRUMA) ABDITA (L. and R. Wesson)

Plate I, fig. 3

*Strumigenys* (*Cephaloxys*) *abdita* L. and R. Wesson, 1939, *Psyche* 46:106-107, Pl. 3, fig. 6, worker. *Strumigenys* (*Trichoscapa*) *abdita* M. R. Smith, 1947, *Amer. Midl. Nat.* 37:587.

*Worker*: TL 2.04-2.36, HL 0.51-0.59, WL 0.51-0.59, CI 69-74, MI 18-22. Measurements taken from 42 specimens, including the types, and representing at least five separate colonies from Ohio, Indiana and Pennsylvania.

The description and figure given by the Wessons fits this ant rather well, although I believe that they have underestimated the average total length and overestimated slightly, especially in their figure, the exposed length of the mandibles. The specimens I have examined, including the types, do not have convergent preocular laminae strictly speaking, but rather the laminae are convex and have a feeble notch just behind the point where they join the lateral clypeal borders. Clypeus  $1\frac{1}{4}$  to  $1\frac{1}{3}$  times as broad as long, broadly subtruncate anteriorly, the anterior border feebly convex and meeting the convergent sides through even curves. Occipital lobes broadly rounded and definitely expanded laterally.

Mandibles large and sturdy, very distinctly diastemate, weakly arched and the apices downcurved. The acute basal lamella is usually visible at or just anterior to the clypeal border when the mandibles are fully closed; following this, the diastema is longer than the length of the lamella. Principal apical series of 4 stout triangular teeth, no. 2 slightly the longest (nearly or quite as long as the basal lamella) and no. 3 the shortest of this series. The two intermediate teeth beyond the principal series much smaller. In general, the mandibles are distinctly larger, more strongly toothed and with a larger diastema than in the *talpa* group, but series vary somewhat in mandibular development.

Antennal scape in average-sized specimen 0.28 mm. long, only weakly bent near base, gently incassate. Pronotum laterally submarginate; humeral angles usually bluntly angulate, rarely very weak. Promesonotum and propodeum in profile forming two convexities, of which the propodeal convexity is very feeble, meeting at the feebly depressed metanotal groove. Propodeal teeth more or less elevated; infradental lamellae deeply excised above, but widened subangularly below. Basal gastric costulae short, usually not extending more than  $\frac{1}{4}$  the length of the basal gastric tergite. Pronotal carinula absent or very feeble.

Sculpture as usual in Nearctic *Smithistruma*; sides of alitrunk largely smooth and shining. Clypeal pilosity distinctive, but varying slightly from one nest series to another; consisting of broadly spoon-shaped and spatulate hairs, erect, but with the broadened portions bent sharply anteriorly, those on the center of the slightly convex disc as large or nearly as large as those along the margins, the latter numbering 7-10 on each side of the midline. The hairs are whitish-transparent and give a woolly appearance, noted by the Wessons, when observed at low magnifications. Hairs of cephalic dorsum posterior to the impressed frontal area and those of the anterior scape borders suberect or erect, broadly spatulate or spoon-shaped apically, gradually becoming more slender on the occiput. Posterior occipital region with one or two pairs of slender filiform or subfiliform specialized hairs; each occipital lobe with one of these hairs on its lateral border. The pilosity is very fragile and easily rubbed off; without it, the habitus of the insect is very radically altered. Humeral and mesonotal tubercles each with a long flagelliform or filiform hair in perfect specimens. Usually 3 or 4 pairs of short, erect or suberect spatulate hairs and a sparse growth of reclinate filiform and subfiliform hairs on the alitrunkal dorsum when pilosity is complete. Hairs of nodes and gaster fine and rather long, mostly erect, with truncate or sometimes even very feebly subclavate apices.

Color ferruginous yellow.

*Gynetype female*, dealate: TL 2.72, HL 0.60, WL 0.66, CI 76, MI 22. Differs from the worker in the usual ways. Mesonotum with a few delicate longitudinal rugulae in the middle and a fairly abundant growth of filiform hairs, most of which recline poste-

riad. Gastric costulae fine, extending about  $1/3$  the length of the first gastric tergite. Color darker than in workers; medium ferrugineous. Gynetype taken from a nest of workers resembling very closely the *lectotype* (see below); nest in a pile of stones on Gibraltar Island in Lake Erie, Ohio (Mary E. Amstutz).

*Male unknown.*

*Material examined*, with special remarks on variation: *Type locality*: Jackson, Ohio (L. and R. Wesson). Taken under boards and pieces of slate in a back yard in the town. There were originally three worker cotypes; although no holotype has been designated in print, the specimen, unfortunately damaged, in the MCZ bears the author's label "holotype" and should be regarded as *lectotype* (by present designation).

The "typical form" of this species, with pilosity and mandibles as described above, is represented by specimens from the type locality and from the large Gibraltar Island series (see under gynetype above), as well as by part of the specimens from Catawba Beach, Ohio (M. E. Amstutz; Mary Talbot) and two specimens from a bluff along Spring Creek, Centre Co., Pennsylvania (W. L. Brown). The last-named locality is at 1200 feet altitude in an Appalachian north-south valley. The remainder of the Catawba Beach specimens, which may represent one or more than one colony, differ in having shorter mandibles (MI 18 or 19) than are usual in the "typical" form, and the pilosity is also different in a few minor respects. The few long specialized hairs of the occipital region, gastric dorsum, humeri, etc., are developed as extremely long, fine, attenuated and straggling flagelliform hairs, and the hairs of the clypeus are slightly smaller and less numerous, with the blades mostly turned edge-on to dorsal view, so that at first glance they appear rather narrow. A small, rather badly depilated series from Turkey Run, Indiana (Mary Talbot) agrees well as far as can be determined with the series just described, and the mandibles are rarely as long as MI 19. Before seeing the two Ohio series sent by Miss Amstutz, I was seriously considering describing the Catawba and Turkey Run variants as a new species.

This species undoubtedly has a wider range than the few records indicate. It appears to be a soil-dweller, and for this reason has probably been overlooked in many of the northeastern areas where it should occur. The records are decidedly northern for a *Smithistruma*, and it seems significant that this ant, in all cases but that of Turkey Run, has been taken in localities where *S. (W.) pergandei* is also known to occur. It should be looked for in New York, northern Illinois and in the Appalachians farther south. Nesting sites and foraging areas for this species as known are typically under stones or other objects lying on the soil surface in either shaded or somewhat open situations. The broad clypeus and the broadly diastemate mandibles indicate a possible relationship to the *pulchella* group, and the same characters also suggest distant affinities with the subgenus *Wessonistruma*.

KEY TO SMITHISTRUMA OF NORTH AMERICA\*

(Refer to Plates and text-figures)

1. Mandibles very nearly as long as to longer than the clypeus, with a toothless diastema equalling or exceeding in length the space occupied by the apical series of teeth ..... *Smithistruma (Wessonistruma)* Brown 2
- Mandibles considerably shorter than the clypeus; toothless diastema absent or smaller ..... *Smithistruma* s. str. 3
2. Sides of clypeus meeting anterior border through distinctly rectangular corners (apical mandibular teeth all acute; dorsa of petiole and postpetiole without reclinate spatulate hairs; size small, HL under 0.60. Mississippi Valley and Gulf States) ..... *angulata* (M. R. Smith)
- Sides of clypeus passing into anterior border through evenly rounded corners (apical series of teeth alternating acute and low, rounded lobes; dorsa of petiole and postpetiole with reclinate spatulate hairs; size larger, HL more than 0.60. (N.E. States to Iowa, s. to E. Tennessee) ..... *pergandei* (Emery)
3. Dorsum of gaster largely striolate-punctulate and opaque or nearly so, with stout, erect spatulate hairs (spongiform processes of petiole and postpetiole obsolescent, belongs to Neotropical group. Gulf States to West Indies and S. Mexico) ..... *margaritae* (Forel)

\* Based on workers, tropical Mexican species omitted.

- Dorsum of gaster smooth and shining when clean, with a row of short longitudinal costulae at base, gastric pilosity long and weak (spongiform processes of petiole and postpetiole well developed) ..... 4
4. Hairs of entire clypeal surface broad, white, scale-like and densely arranged, all appressed, including those on the free border (Mississippi) ..... *rohweri* (M. R. Smith)
- At least some clypeal hairs outstanding or forming a projecting fringe along some part of the free border ..... 5
5. Clypeus forming a blunt raised point anteriorly (point bearing a concentrated group of 8-10 slender, outwardly radiating hairs ..... *dietrichi* (M. R. Smith)
- Anterior clypeal border rounded (clypeal hairs not concentrated as above, or else with strongly bulbous apices) ..... 6
6. Clypeus with a group of 8-10 hairs with strongly bulbous apices radiating from a small anteromedian area (clypeus also with two very long, curved, narrow erect hairs arising one on each side near the midlength; surface otherwise practically naked. E. U. S.) ..... *ornata* (Mayr)
- Clypeal pilosity not as described ..... 7
7. Clypeus weakly concave, shining, its free border sharply bimarginate; clypeal pilosity rather sparse, extremely so in the center (mandibular diastema well developed and distinct at full closure. E. U. S.) ..... 8
- Free clypeal border single, or, if indistinctly bimarginate, then the clypeal surface mostly weakly convex, with pilosity more dense and uniformly distributed and the mandibular diastema very weak and indistinct at full closure ..... 9
8. Hairs on clypeus and upper dorsum of head very fine, not or extremely indistinctly apically broadened; 2 or more hairs near the midlength of clypeus erect, very long and fine, somewhat crookedly flagelliform. (S.E. U. S.) ..... *flirrhina* Brown
- Principal clypeal hairs each with a small but distinct broadening, often appearing feebly fishtail-like at high magnifications, at the extreme apex; hairs on upper cephalic dorsum also with enlarged tips, uniform in length and curved anteriorly. (E. U. S.) ..... *bimarginata* (L. & R. Wesson)
9. Hairs on sides of clypeus fine, mostly distinctly J-shaped, curved posterolaterally (mandibles large, MI 21-26, diastema very feebly developed and indistinct; clypeus opaque, minutely tuberculate. E. U. S.) ..... *ohioensis* Kennedy & Schramm)
- Hairs on sides of clypeus either distinctly apically enlarged or not J-shaped (mandibles smaller or with a well developed, distinct diastema) ..... 10
10. Clypeus approximately as wide as long and about half as wide as the width across the occipital lobes; mandibles somewhat convex dorsally, diastema very small and indistinct, especially at full closure (head with mandibles cuneiform, the preocular laminae straight and distinctly converging anteriorly; CI 63-69) ..... 11
- Clypeus distinctly broader than long and more than half as wide as the width across the occipital lobes, or, if width of clypeus is ambiguous, then the mandibles depressed and with a distinct diastema (preocular laminae parallel or very weakly converging, often convex; head not or imperfectly cuneiform in outline) .. 14
11. Clypeal surface covered densely with short, scale-like appressed hairs, free border with a close fringe of anteriorly-directed linear-spatulate hairs. (E. U. S.) ..... *clypeata* (Roger)
- Hair on clypeal surface not appressed or scale-like, erect or suberect, those projecting from the free border narrow ..... 12
12. Clypeal hairs, including those in the center, very fine, with finely tapered apices, curving gently and obliquely away from the midline (clypeus distinctly shining, yellowish, E. U. S.) ..... *laevinasis* (M. R. Smith)
- Clypeal hairs slender, but with apices feebly broadened or at least not finely tapered, those in the center shorter and with definitely enlarged apices ..... 13
13. Clypeus distinctly shining (N. Carolina to Gulf States; see discussion in text) ..... *brevisetosa* (M. R. Smith)
- Clypeus indistinctly shining to nearly completely opaque (Virginia to Illinois; see

- discussion in text) ..... *pilinasis* (Forel)
14. Most or all of the large hairs on the sides of the clypeus curved away from the midline (and broadened at their apices) ..... 15  
 Most or all of the large hairs on the sides of the clypeus curved anteriorly or anteromedially (apices broadened or not) ..... 16
15. Head robust (CI over 70); clypeus broad, with an irregular free border, its center depressed and without visible pilosity (E. U. S.) ..... *reflexa* (L. & R. Wesson)  
 Head narrower (CI 70 or less); clypeus only slightly broader than long, weakly convex, entirely covered with abundant short, fine posteriorly-inclined hairs (form of head and mandibles as in *talpa*. N. Carolina) ..... *trayi* Brown
16. Hairs fringing free clypeal border finely filiform, not sensibly broadened (form of head and mandibles as in *talpa*. Arkansas) ..... *filitalpa* Brown  
 Hairs fringing free clypeal border spatulate or spoon-shaped, although sometimes narrowly so ..... 17
17. Pilosity of upper dorsum of head consisting entirely and uniformly of short, curved spoon-shaped hairs ..... 18  
 Pilosity of upper dorsum of head not uniformly spoon-shaped; at least a few slender erect or suberect hairs present on occiput (lateral borders of occipital lobes often each with one or two long, weak outstanding hairs) ..... 19
18. Clypeus only very slightly broader than long, its free border lateral to the external margins of the closed mandibles with 6-7 small, crowded spatulate hairs (mandibular diastema longer than length of basal tooth; apical series with only 4 principal teeth. S.E. U. S.) ..... *creightoni* (M. R. Smith)  
 Clypeus very distinctly broader than long, its free border lateral to the external margins of the closed mandibles with 4-5 larger, spaced spatulate hairs (mandibular diastema shorter than length of basal tooth; apical series with 5 principal teeth. S.E. U. S.) ..... *bunki* Brown
19. Mandibles coarsely and continuously toothed, without a diastema ..... 20  
 Mandibles with a distinct toothless diastema ..... 21
20. Hairs on sides of anterior clypeal border elongate, narrow, curved semicircularly toward the midline (anterior clypeal border usually very feebly emarginate in the middle; infradental lamellae of propodeum narrow and concave; size large, HL usually well over 0.60. E. U. S.) ..... *rostrata* (Emery)  
 Hairs on sides of anterior clypeal border rather short and broadly spatulate (anterior clypeal border transverse, barely emarginate; infradental lamellae broadened and convex; size smaller, worker HL probably 0.60 or less. California, possibly a tramp) ..... *californica* Brown
21. Hairs fringing free clypeal border narrowly spatulate, crowded, about 9 on each side of the center, all curved medially and anteriorly (most hairs on upper dorsum of head long, fine, reclinate or subreclinate; clypeus not or only very slightly broader than long. E. U. S.) ..... *talpa* (Weber)  
 Hairs fringing free clypeal border larger, broadly spatulate or spoon-shaped, often 7 or less on each side of the center (clypeus distinctly broader than long) ..... 22
22. Clypeal surface with a uniform covering of large, curved spoon-shaped hairs (mandibles long, MI 18-22, apical series with 4 stout principal teeth. Pennsylvania to Indiana) ..... *abditia* (L. & R. Wesson)  
 Clypeal surface without hairs in the center, or the hairs in the center much reduced, appressed and inconspicuous (MI 13-18. E. U. S.) ..... 23
23. Head narrow, CI 61-68, mandibles slender (the lateral border of each occipital lobe with a long, fine dorsolaterally curved flagelliform hair. E. U. S.) ..... *pulchella* (Emery)  
 Head more robust, CI 67-72, mandibles robust and convex (lateral borders of occipital lobes without true flagelliform hairs. E. U. S.) .....  
 ..... *missouriensis* (M. R. Smith)

#### NEOTROPICAL SPECIES OF SMITHISTRUMA

In the following summary, 15 species of the genus, belonging to two subgenera, are recognized for tropical America. The two subgenera are *Smithi-*

*struma* s. str., with 14 species belonging to three or more species-groups; and *Platystruma* new subgenus, raised for the very aberrant species *depressiceps* (Weber).

The nominate subgenus is represented by a characteristic Neotropical fauna, here divided into the *alberti*, *schulzi* and *ornata* groups. The last-named group is represented by a single species, presently known only from Trinidad. This is *S. hyphata* new species, which is placed with the Nearctic species *ornata* and *dietrichi* more because of similar habitus than for any other reason.

The *alberti* group is rather diverse, although only five species are assigned to it here. It may be divided into two subgroups, *alberti* and *nigrescens* in one and *consersa*, *friderici-mülleri* and *sublucida* in the other.

The *schulzi* group contains eight presently known forms, all rather similar and showing relationship through species like *epinotalis* to the *alberti* group. The *schulzi* group species are mostly arboreal or subarboreal plant-cavity dwellers. Since this group probably contains a much greater number of species than is recognized here, the accurate characterization of the imperfectly known forms *schulzi* and *emiliae* will be needed in order to prevent taxonomic confusion in the group.

In general, the South American fauna in this genus appears to have no close, clearcut relationships with that of any other zoogeographical region. The relationship between the *alberti* group and the Indo-Papuan *capitata* group seems about as close and certain as any, but even this is open to more than one interpretation.

The Neotropical fauna does seem rather sparse when compared to that of eastern North America, but this sparseness probably reflects lack of proper collecting more than anything else. I am convinced that tropical America will yield very many more species when modern collecting techniques, such as use of the Berlese funnel, are employed in rich areas like the Amazon Basin and Colombia. It is probable that the new species remaining to be found will tell us much more about the faunal relationships. Meanwhile, I may guess that the Neotropical fauna is an old one, its stock probably representing an earlier wave or waves of migration from the Old World than that which gave North America its fauna.

Subgenus SMITHISTRUMA sensu stricto  
ALBERTI GROUP

Five species, all Neotropical. Basal lamella of mandible broad, either with rounded apex or else broadened into a straightedged translucent lamina. Postpetiole and much of the sides of the alitrunk smooth and shining. Spongiform appendages of petiole and postpetiole usually well developed. The *alberti* subgroup contains two species, one (*alberti*) common throughout much of tropical America, the other (*nigrescens*) in the Caribbean region. The *consersa* subgroup contains three species concentrated in southern Brazil and northern Argentina.

SMITHISTRUMA (SMITHISTRUMA) ALBERTI (Forel)  
Pl. II, fig. 17; Pl. III, fig. 27

*Strumigenys alberti* Forel, 1893, Trans. Ent. Soc. Lond. pp. 380-381, worker, female.  
*Strumigenys alberti* Emery, 1894, Bull. Soc. Ent. Ital. 26:Pl. 1, fig. 5, worker. Wheeler,



1908, Bull. Amer. Mus. Nat. Hist. 24:148, worker, in key. Mann, 1922, Proc. U. S. Nat. Mus. 61(13):39, worker, part., from Honduran localities, not other localities cited. *Strumigenys alberti* var. *intermedia* Wheeler, 1913, Bull. Amer. Mus. Nat. Hist. 32:242, worker. (new syn.) *Strumigenys* (*Cephaloxys*) *alberti* Emery, 1922, Gen. Ins. Fasc. 174:325, var. *intermedia* also listed. *Strumigenys* (*Cephaloxys*) *alberti* subsp. *guianensis* Weber, 1934, Revista de Ent. 4:50, worker. (new syn.)

*Worker*: TL 2.21-2.66 (2.35-2.55), HL 0.52-0.61 (0.55-0.59), WL 0.60-0.67, CI 76-81 (77-79), MI 30-33. Measurements made in detail on 51 workers from among 185 workers in which HL was measured, representing at least 24 colonies from all the localities listed below and including cotypes of *alberti* and *alberti guianensis* and size extremes among the specimens examined. The type of *intermedia* was compared directly with previously measured specimens and proves to be entirely within the ranges given above.

Head broadly subcuneiform, with a deep, broad semicircular posterior excision; occipital lobes expanded laterally and rather narrowly rounded posteriorly, sides of lobes weakly to moderately convex in front and converging rather sharply. Precular laminae weakly to distinctly convex and gently converging anteriorly, the lateral cephalic outline from dorsal view discontinuous to subcontinuous. Clypeus diamond-shaped, but with a more or less broadly rounded anterior border; sometimes the anterior border showing an indication of very obtuse, rounded subangulation in the center. Clypeal disc slightly broader than long and about  $2/5$  the width across the occipital lobes, feebly convex from side to side, the anterior strip in front of a line connecting the lateral clypeal angles darker in color and feebly depressed, suggesting the more strongly depressed anterior clypeal apron seen in *Serrastruma* species.

Mandibles large and robust, porrect, with only moderate ventral deflection of the apices; approximately as long as the clypeus; somewhat depressed, only feebly convex dorsally. Dentition very characteristic and constant in all series; teeth nos. 1 and 2 of the principal series fused and broadened and forming with the long basal lamella a wide, straight-edged translucent lamina occupying slightly more than half the length of the apical (masticatory) border; the coalescence of the first two apical teeth with the basal lamella is nearly complete, the only remaining separation being a fine linear notch (see fig. 17). Antennal scapes approximately as long as the distance from the apex of the closed mandibles to the posterior clypeal angle, or in absolute terms, 0.41-0.44 mm. long. Bend of scape gentle (ca.  $30^\circ$ ), coming at about the basal third; distal of the bend, the shaft gently incassate, greatest breadth near the midlength. Funiculi about  $1\frac{1}{2}$  times as long as the scapes, rather slender; apical funicular segment slightly longer than segments I-IV together; IV approximately equal in length to I and to II + III; II and III both a little longer than broad, II slightly the longer.

Eyes moderately developed, weakly convex, each with about 5 or 6 facets in the greatest diameter; situated on the ill-defined lower scrobal borders a trifle posterior to the cephalic midlength; not usually visibly protruding at the sides when the head is seen from dorsal view.

Alitrunk in profile forming a long, even promesonotal convexity and a short, slight propodeal convexity, the two almost continuous, interrupted by a feeble depression centering on the distinct but shallow metanotal groove. Pronotum with a rounded, sharply marginate anterior border and bluntly indicated humeral angles. Promesonotal suture obliterated on the dorsum, but the median carinula of the promesonotum quite distinct. Mesonotum feebly marginate laterally; propodeal surface very slightly longer than broad, submarginate along the sides. Propodeal teeth compressed, strongly acute,  $1/2$  to  $3/4$  as long as the distance between the centers of their bases, elevated and slightly divergent posteriorly. Infradental lamellae very narrow, but not so much reduced as in *margaritae*; edges concave to nearly straight.

Petiolar node about as long as its peduncle, seen from the side subglobose, but seen from dorsal view feebly subquadrate and distinctly wider than long; a pair of very fine carinulae extend, one on each side of the anterior nodal face, from the summit down onto the peduncular dorsum. Ventral longitudinal spongiform strip present and distinct, but fairly narrow; posterior collar developed into a moderate triangular lobe on each side behind; the greater part of the sides of the node free. Postpetiole transversely ovate, only about  $1\frac{1}{4}$  times as wide as the petiolar node; disc evenly convex and usually smooth, shining, surrounded by well developed spongiform masses. Gaster usually fairly bulky, not noticeably depressed, with a narrow transverse anterior spongiform margin and a heavy

anteroventral pad; basal costulae averaging 11-14 in number, coarse and well separated, extending  $1/4$  to  $1/3$  the length of the basal gastric tergite. Remainder of gaster smooth and shining.

Sculpture of the pattern usual in *Smithistruma*; head, alitrunk and petiole evenly and densely punctulate; promesonotum in some specimens with a partial suggestion of feeble longitudinal striation or rugulation. In the smallest specimens, the promesonotal sculpture often partially effaced, appearing feebly subrugulose and in some places weakly shining. Sides of posterior alitrunk, and sometimes a small part of the sides of the pronotum, smooth and shining. Mandibles and appendages feebly and very finely sculptured, for the most part subopaque.

Ground pilosity very scarce on promesonotum, more abundant but still rather sparse on the cephalic dorsum, composed of linear-spatulate subreclinate hairs, those on the clypeal disc finer and shorter than those on the verticociput, all or nearly all directed anteriorly. Fringing hairs of free clypeal border crowded, larger than those on the disc, but still not very conspicuous, 6-7 on each side of the middle, all narrowly spatulate and curved medially. Anteriorly fringing hairs of scape slender and linear-spatulate or subspatulate, 6-7 in number, all curved distad except the third and fourth from the base, which are curved basad.

Posterior occiput with a transverse row of four stiff, erect, narrowly spatulate hairs, of which the outer two are sometimes subreclinate and scarcely distinguishable from the ground pilosity. Additional central pair of the same present or absent on the vertex; long lateral hair on the side of each occipital lobe flagelliform. Humeral and mesonotal pairs flagelliform. Nodes each with about four, gaster with four or five transverse rows of four each long erect or suberect hairs, all more or less posteriorly curved. These hairs are rather stiff, and may either be truncate apically or with a short, fine apical attenuation, the latter sometimes looped back against the shaft of the hair, causing it to appear spatulate at first glance.

Color varying rather widely from very light ferrugineous yellow to deep brownish ferrugineous, the variation not territorial, but one nest usually relatively uniform if obvious teneralers are not considered. Usual color is medium to medium-deep ferrugineous.

*Female:* TL 2.95-3.11, HL 0.60-0.65, WL 0.81-0.85, CI 80-83, MI 28-30. Eight females from widely different parts of the range were measured. Among these, there was slight variation in color, size, proportions and length of propodeal teeth.

Differing from the worker in the usual full sexual attributes. Head more broadly and shallowly excised behind. Mandibles about  $9/10$  the length of the clypeus. Mesonotum with median carinula very weak or absent, except on scutellum, where it is strong and complete, posteriorly helping to form a small but distinctly jutting point. Petiolar node seen from above twice as broad as long, the anterior border straight and transverse. Propodeal teeth much shorter, blunter and farther apart than in the worker. Venation of the forewing in a specimen from Campinas, Brazil: R + Sc, stigma, and 2r sharply defined and weakly pigmented; Rsfl, M + Mfl, CuA and Rsf5 present, but poorly defined and weakly pigmented; Mf4 indicated as a groove; basal stub of Rs + M present. Body color varying from light to very dark ferrugineous, gaster often darker; color in general usually darker than in workers of the same colony.

Male volsella as in fig. 27. Remainder of male body not described because of a lack of suitable specimens.

*Remarks:* The taxonomic background of *alberti* and its supposed subspecies and varieties is extremely confused. As of 1948, the classification summarized below was unchallenged:

*alberti* Forel, 1893

var. *nigrescens* Wheeler, 1911

var. *intermedia* Wheeler, 1913

var. *nana* Santschi, 1930

subsp. *guianensis* Weber, 1934

subsp. *longipilis* Weber, 1934

I have managed to see types of all of these forms except *nana*, and in this case, I have specimens from some of the same Cuban series Santschi had on hand and mentioned in the original description. Among this entire aggregation of specimens, I can distinguish two and only two forms. One form is larger, with large mandibles having dentition as in fig. 17; the types of *alberti*, *intermedia*, and *guianensis* represent this species. These three are identical, and therefore take the prior name *alberti*. The other form is smaller,

with relatively shorter and more delicate mandibles having dentition as in fig. 15. This dentition was described in detail by Weber in 1934 (loc. cit.), but under the name *alberti*. Belonging to this second form are the types of *nigrescens* and *longipilis*, and presumably that of *nana*. The prior name, unfortunately, is *nigrescens*, and this will have to be applied. I say unfortunately because the unique type of *nigrescens* is a very dark-colored worker, while the very great majority of the specimens I have seen belonging to this species are light ferrugineous in color. Very dark variants are not at all unusual among Neotropical dacetinae species, and I do not think it wise to consider the dark and light forms as taxonomically distinct unless it can be proven that the coloration is apportioned territorially on a fairly large scale. In my opinion, there are indications in the presence of intergradient color forms that territorial apportionment does not hold very well in this case.

The confusion with regard to these two species dates back to Wheeler (1913, loc. cit.), who consistently misidentified Cuban forms (*nigrescens*) as *alberti*. The true *alberti*, when found, was named as an infraspecific variant twice, by Wheeler and Weber. European workers, on the other hand, correctly identified *alberti*, but placed the smaller form as an infraspecific variant to it. Following Wheeler, all American workers have considered the small form from Cuba as the typical *alberti*, whereas the true *alberti* has not yet been taken on Cuba. That the two species are completely distinct as such is shown both by the constantly different mandibular dentition and by the striking difference in body size; furthermore, both species occur together in abundance along the Gulf Coast of Costa Rica without producing the slightest sign of intergradation. *Alberti* occurs from southern Mexico to Bolivia and on certain of the Lesser Antilles, but not in the Greater Antilles; I believe that its occurrence even in the Lesser Antilles must be due to relatively recent introduction. The type locality of *nigrescens* is Jamaica, and it is no doubt common there, since it is unusually abundant and widespread through Cuba and Haiti. On the mainland, *nigrescens* has been taken only on the Gulf Coast side of Costa Rica; Dr. Weber has more recently captured a colony on Trinidad. While it seems probable that *nigrescens* acts as a tramp in the Caribbean area, its original range is open to question.

*Material examined (alberti)*: Two cotypes [type material deposited in Forel Coll.]

*Type locality*: St. Vincent, B. W. I. (H. H. Smith).

MEXICO: Tetzonapa, Vera Cruz, one stray worker (H. S. Dybas); El Palmar, 16 km. west of Tetzonapa, Vera Cruz, 600 feet altitude, forest around rubber and coffee plantations; two colonies from rotten logs, one containing 130 workers, 3 dealate females (F. G. Werner). St. Lucrecia, Tehuantepec (W. M. Mann).

HONDURAS: Cecilia; San Juan Pueblo (W. M. Mann).

COSTA RICA: Zent; Colombiana Farm, Santa Clara Prov.; Estrella Valley (W. M. Mann). Hamburg Farm, Santa Clara Prov., several colonies (F. Nevermann).

PANAMA CANAL ZONE: Barro Colorado I.; Rio Chinillo, series from several colonies (J. Zetek).

DOMINICA, B. W. I.: Long Ditton near Roseau (Crampton, Lutz and Miner) type of var. *intermedia*, a unique. Another collection, a series containing winged females and workers, was taken by the same collectors at Laudet in 1911. Type of *intermedia* in AMNH.

BRITISH GUIANA: Kartabo (W. M. Wheeler) type series of subsp. *guianensis* [MCZ].

BRAZIL: Campinas, Goyaz (Schwarzmaier).

BOLIVIA: Covendo; Huachi, Rio Beni (W. M. Mann).

Biological data accompanying six of the series indicate that the nests are established by preference in rotten logs either in forest or in partial clearings. The records suggest that this species may have the widest range of any *Smithistruma* species; it will probably prove to be the commonest species of the genus throughout most of the tropical American mainland. The close resemblance between *alberti* and the larger species of the Indo-Papuan *capitata* is very striking, and possibly indicates a real phylogenetic relationship. *Alberti* is not likely to be confused with any species but *nigrescens*, and the differences are thoroughly discussed above, below, and in the key.

#### SMITHISTRUMA (SMITHISTRUMA) NIGRESCENS (Wheeler)

Pl. II, fig. 15

*Strumigenys alberti* var. *nigrescens* Wheeler, 1911, Bull. Amer. Mus. Nat. Hist.

30:28, worker. *Strumigenys* (*Cephaloxys*) *alberti* var. *nigrescens* Emery, 1922, Gen. Ins. Fasc. 174:325. *Strumigenys* [and *S. (Cephaloxys)*] *alberti* of various American authors, not Forel, 1893. See Wheeler, 1913, Bull. Mus. Comp. Zool. Harvard 54:496. *Strumigenys* (*Cephaloxys*) *alberti* var. *nana* Santschi, 1930, Bull. Soc. R. Ent. Egypte 14:80, worker. (new syn.) *Strumigenys* (*Cephaloxys*) *alberti* subsp. *longipilis* Weber, 1934, Revista de Ent. 4:50, worker. (new syn.)

Worker: TL 1.78-2.08, HL 0.46-0.52, WL 0.42-0.51, CI 71-76, MI 21-24, ICD 51-54. Measurements and proportions from 45 workers from among over 200 workers examined, including size extremes and representing at least 25 separate colonies from Cuba, Haiti, Costa Rica and Trinidad.

This is the common species in the Greater Antilles, and with the possible exception of *S. margaritae*, seems to be the only member of the genus that has been found in these islands. Prior to November, 1949, determined specimens I returned to various correspondents bore the label "*alberti*," while true *alberti* specimens were determined by me as "*guianensis*." Up to that month, I had not been aware that the older American determinations were incorrect. Since specimens of both species, whether or not correctly labelled, occur in most collections of any size, and since *nigrescens* is so similar to *alberti* in most respects, I present here a comparative description.

Head as in *alberti*, but a little narrower and with the sides of the head not so nearly continuous in outline. Clypeus slightly broader than long, the curve of the free border more transverse anteriorly, but still feebly convex here, the resultant anterolateral "corners" evenly rounded. Mandibles depressed, always shorter than the clypeus (averaging about 4/5 as long as the clypeus considering the exposed length at full closure) and with dentition very constant in pattern, as shown in fig. 15.

Antennal scape (average L about 0.24 mm.) bent at about a 35° angle near its basal third, only weakly incrassate, thickest at or a bit distad of it midlength. Average length of funiculus about 0.40 mm.

Alitrunk like that of *alberti*, but relatively more slender, slightly more depressed, with the metanotal groove less distinct and often entirely effaced. Humeri obtusely angulate, with small but distinct piligerous tubercles; paired lateral mesonotal tubercles small but distinct, forming low, rounded lamelliform lobes. Propodeal teeth translucent, acute, a little shorter relatively than in *alberti*, and usually approximately half as long as the distance between the centers of their bases, continuous with the infradental lamellae; the lamellae varying slightly in width from series to series, usually rather narrow and gently concave, but always wider than in *alberti*; in some specimens, there is a weak indication of angulation or convexity at the ventral extremities.

Petiolar and postpetiolar nodes relatively much less robust than in *alberti*. Petiolar node more than half again as long as broad and seen in profile, rather narrowly rounded above. Spongiform appendages voluminous, slightly better developed than are those of *alberti*. Gaster rather small, basal segment taking up 2/3 or less the total gastric length. Basal costulae few and well separated, 11-15 in number, extending about 1/5 to 1/4 the length of the basal segment.

Sculpture weaker than in *alberti*. Pronotal punctulation variable, often partially effaced or replaced by feeble, indefinite longitudinal striation, the surface often subopaque or even partially weakly shining. Median carinula usually well developed and extending the length of the pro- and mesonotal dorsa. Punctulation of petiolar node often partially effaced, the surface subopaque or even weakly shining. Postpetiolar disc, gastric surface, sides of alitrunk including most of lateral pronotal surfaces, smooth and shining.

Ground pilosity of head as in *alberti*, but the hairs shorter and less conspicuous, more mesally directed. Long erect hairs of occipital region as in *alberti*, but more slender; no median pair present on the vertex; pair of flagellate hairs on the lateral occipital borders very long, fine and straggling. Alitrunk with extremely few, very inconspicuous subapressed, weakly spatulate ground hairs. The specialized flagellate hairs of the body are usually quite long, very fine and straggling, not or very rarely broken off at midlength and usually not folded back upon themselves "buggy-whip fashion" as those of *alberti* so often are. These long hairs are placed one on each of the paired humeral and mesonotal tubercles, and on the nodes and gaster are arranged as in *alberti*, i.e. in rough rows of four each on the gastric dorsum.

The hairs of the *longipilis* type are not longer than is usual in undamaged specimens

of this species, but they are covered with dust in such a way that they are more conspicuous than usual.

Color of most series light ferrugineous yellow to medium ferrugineous, gaster and sometimes dorsum of head very feebly darkened. The *nigrescens* type specimen is dark ferrugineous, the head and gaster deep mahogany. According to the original description, the type specimen (holotype) of *nana* is intermediate in color.

*Gynotype female, alate*: TL 2.27, HL 0.51, WL 0.58, CI 80, MI 24, forewing L ca. 1.8 mm. Differs from the worker in the usual ways. Erect feebly spatulate hairs of the head present in the normal "*Strumigenys* pattern," with a pair straddling the ocellar triangle and a transverse row of four on the posterior occiput. Flagelliform hairs as in the worker, similarly placed. Scutum feebly longitudinally rugulose in the center, with a median carinula; scutal hairs subflagellate, curved posteriorly. Color bright ferrugineous; ocellar triangle deeply infuscated.

*Gynotype* taken at Hamburg Farm, Santa Clara Province, Costa Rica, March 25, 1925 (F. Nevermann); deposited in USNM. Male unknown.

*Material examined*: Holotype [AMNH]; type locality: Mandeville, Jamaica (Wight).

CUBA: Baracoa; Mina Carlota (W. M. Mann). Soledad, Cienfuegos (W. S. Creighton; N. A. Weber). Cayamas, *longipilis* holotype (E. A. Schwarz). Cumanyagua; Mina Carlota (W. S. Creighton), parts of original nest series mentioned in *nana* description. Mina Carlota (G. Salt). Havana (A. Bierig). Cienaga de Zapata (W. M. Wheeler).

HAITI: Mts. n. of Jacmel; Diquini; Petionville (W. M. Mann).

COSTA RICA: Hamburg Farm, Santa Clara Prov., series from 3 different colonies.

TRINIDAD: Without further locality (N. A. Weber, No. 37).

*S. nigrescens* is a very common ant in Cuba, occurring in all sort of habitats. It is known from one end of the island to the other in agricultural as well as wilder districts. It appears suspiciously like a tramp species in distribution and behavior; though it may originally have come from Central America, there appears to be no way of ascertaining its original distribution. Many of the reported colonies were found nesting under stones. Extensive collecting has not revealed its presence on Puerto Rico.

If the typical dark-colored *nigrescens* is found to represent a distinct geographical color race inhabiting Jamaica, the light-colored populations will have to take the name *nana* Santschi. I have stated above that I regard the taxonomic distinctness of the dark form as improbable.

#### SMITHISTRUMA (SMITHISTRUMA) FRIDERICI-MÜLLERI (Forel)

##### Pl. II, fig. 21

*Strumigenys friderici-mülleri* Forel, 1886, Mitt. Schweiz. Ent. Ges. 7:213, 216, worker. *Strumigenys friderici-mülleri* Mayr, 1887, Verh. Zool.-bot. Ges. Wien, 37:570; Emery, 1890, Bull. Soc. Ent. Ital. 22:Pl. 8, fig. 1, worker. Wheeler, 1908, Bull. Amer. Mus. Nat. Hist. 24:148, worker. *Strumigenys (Cephaloxys) friderici-mülleri* Emery, Gen. Ins. Fasc. 174:325.

*Worker*: TL 2.01-2.29, HL 0.52-0.53, WL 0.67-0.72, CI 68-73, MI 20-21. Measurements taken from three of four cotypes examined, these all thought to be from the same nest.

*Habitus* somewhat like that of small rostrata workers. Occipital lobes distinctly bulging laterally; preocular laminae very nearly or quite parallel. Clypeus in total outline subtruncate anteriorly, the anterolateral angles broadly rounded, the transverse anterior border weakly convex and the sides converging anteriorly. The anterior border lamelliform, depressed below the level of the broadly diamond-shaped disc. Exposed length of the closed mandibles more than half as long as the clypeus; dorsal mandibular surfaces weakly convex, the outer margins subcontinuous with the sides of the clypeus. The basal and apical borders of the mandibles meet through a very obtuse angle, as in other *Smithistruma*, and are not continuous as Forel states. The dentition of the mandible as shown in the figure is incomplete, due to the fact that the only specimen upon which dissection was risked was damaged in the act. From other specimens examined, however, the third tooth seems to be the longest of the apical series.

Eyes moderate in size. Antennal scapes moderately incrassate, broadest at basal third, only feebly bent, anterior border sublamelliform, evenly rounded.

Alitrunk dorsum in profile evenly and moderately convex; metanotal groove marked by a very feeble impression. Anterior pronotal border broadly rounded and sharply marginate, terminating on each side in a distinct, tuberculate humeral angle; lateral pronotal borders weakly submarginate. Lateral mesonotal tubercles low but distinct. Propodeal teeth moderate in size, about half as long as the distance between the centers of their bases, acute; infradental lamellae narrow and concave, but feebly widened and convex ventrally. Petiole with a long, rather slender peduncle and an abrupt but dorsally rounded node, the latter  $\frac{3}{4}$  as wide as the postpetiolar disc. Postpetiole rather small, transverse, with nearly straight anterior and posterior borders and sharply rounded sides, convex dorsal surface; width of free portion of disc about equal to the distance across the posterior pronotal angles. Both nodes with abundant spongiform tissue. Gaster anteriorly with a broad dorsal border of spongiform material, from this a number of short, fine, subfiliform costulae extend a little way onto the surface of the first gastric segment, which is otherwise smooth and shining.

Sculpture as usual in the genus, except that the punctulation of the anterior part of the pronotum is somewhat effaced, with the result that part of the surface is nearly smooth and moderately shining. Sides of alitrunk and dorsum of postpetiole smooth and shining. Clypeus finely granulose-punctulate and opaque, set rather sparingly with short, subappressed spatulate hairs; free clypeal border with an even fringe consisting of about 8 medially curved spatulate hairs on each side, the four immediately on each side of the center of the anterior portion of the border shorter than those on the sides. Antennal scapes with 6-7 narrowly spatulate hairs on the anterior border. Ground pilosity of rest of dorsum of head consisting of sparsely set, small, slender spatulate hairs. Four long erect subclavate hairs on the occiput and a long, weak flagellate hairs on each lateral occipital border. Humeral and mesonotal tubercles each with a long, prominent flagellate hair; dorsum of alitrunk otherwise with a very few scattered, inconspicuous subappressed subspatulate hairs. Nodes of petiole and postpetiole and gastric dorsum with sparse, very long, weak erect flagellate hairs.

Color medium ferrugineous. Female and male unknown to me.

Redescribed from four cotype workers, three sent by Dr. Ch. Ferrière from the Forel Coll., and one of which has been deposited in the MCZ. The other cotype came from the collection of the Secretariat of Agriculture (Museu Paulista), São Paulo, Brazil. Type locality: Itajahy, Brazil (F. Müller).

#### *Smithistruma* (*Smithistruma*) *sublucida* new species

*Holotype worker*: TL 2.46, HL 0.59, WL 0.56, CI 64, MI 16. Differs from the types of *friderici-mülleri* as follows:

- (1) Humeral angles tuberculate, but not so prominent or sharply angulate.
- (2) Sculpture effaced over most of the alitrunk, with only feeble, superficial shagreening on the posterior pronotum, mesonotum and propodeum. The entire surface of the alitrunk in clean specimens therefore appears smooth and shining. This sculpture is quite different from that of *friderici-mülleri*, which species has the sides of the pronotal dorsum and all of the mesonotal and propodeal dorsa with the usual granulose-punctulate sculpture. In *sublucida*, the dorsum of the petiolar node also has the sculpture somewhat effaced and is weakly shining in most lights.
- (3) Ground hairs of head decidedly larger, more conspicuous and more broadly spoon-shaped than in *friderici-mülleri*; more nearly reclinate or appressed and directed mesad. Two slightly longer erect hairs on the center of the occiput, these with weakly clavate-spatulate apices, and one of the same on each lateral occipital border. Flagellate hairs of nodes and gaster extremely long and fairly abundant, the ones on the gastric dorsum averaging as long as the first gastric segment, very fine, arched back to the integumental surface and appearing like croquet wickets in this respect. Pilosity of alitrunk as in *friderici-mülleri*, but the corresponding flagellate hairs even longer and finer.
- (4) Metanotal groove narrow, but distinct, seen as a notch in profile view of the dorsal outline. Lateral mesonotal tubercles more prominent, subconical.
- (5) Propodeal teeth long, straight, spiniform, almost as long as the distance between the centers of their bases, nearly horizontal; infradental lamellae reduced to low cariniform borders like those of *conspersa*, considerably more reduced than in *friderici-mülleri*. The mandibles were not dissected, but these and the clypeus seem from outside exam-



ination to be much as in *friderici-mülleri*. Seen *in situ*, the mandibles appear to have a rounded basal lamella, partly visible at full closure, and a principal series of five acute teeth and two intermediate acute teeth. The basal costulae of the gaster are well developed and extend about  $\frac{1}{4}$  the length of gastric tergite I. Color medium ferrugineous; gastric segment I dorsally darkened to a light reddish-brown shade.

Holotype [Borgmeier Coll.] taken at Porto Alegre, Rio Grande do Sul (P. Buck) together with the paratypes described below.

Two paratypes (with same data as for holotype) [Borgmeier Coll., MCZ] TL 2.09, 2.33; HL 0.57, 0.59; WL 0.54, 0.56; CI 66, 65; MI 17, 16. Two more paratypes besides the above were seen belatedly from the collection of Sr. Mario Consani; these bear the same data as the holotype and do not differ significantly from the specimens described above [Consani Coll.].

*S. sublucida* may be distinguished from the two closely related forms, *S. friderici-mülleri* and *S. conspersa*, by the largely smooth and shining surface of the alitrunk.

#### SMITHISTRUMA (SMITHISTRUMA) CONSPERSA (Emery)

*Strumigenys conspersa* Emery, 1905, Bull. Soc. Ent. Ital. 37:169, fig. 29, worker. *Strumigenys (Cephaloxys) conspersa* Emery, 1922, Gen. Ins. Fasc. 174:325.

Worker: TL 2.01-2.07, HL 0.52-0.53, WL 0.48-0.50, CI 66-69, MI 19-22.

Emery's original figure shows the head of this species and captures habitus and pilosity features fairly accurately. The specimens from Alta Gracia collected by Bruch seem without a doubt to belong to this species; they differ from Emery's figure only in that the basal lamella of the mandible is a trifle more broadly rounded at the apex (but not so broadly rounded as that of *friderici-mülleri*). *S. conspersa* is closely related to *S. sublucida*, and has somewhat similar pilosity and the same long, spiniform propodeal teeth and cariniform infradental lamellae. The pronotum is entirely punctulate. Color medium ferrugineous. The specimens I have seen are probably all from the same nest, although they came to me through various sources. For this reason, I cannot say anything significant about the variation.

The species is similar in many ways to *S. rostrata*, and its presence as far south as Cordoba indicates that it is a temperate climate form. I rather incline to the belief that the resemblances to *rostrata* may be due to convergence.

Type locality: Argentina (F. Silvestri). Types in Emery Coll.

Material examined: Four workers, Alta Gracia, Cordoba (C. Bruch).

#### SCHULZI GROUP

A compact group of small species restricted to the New World in tropical and subtropical regions. A number of characters link them, though not all of the species agree perfectly in showing all of these features. The best universal character lies with the sculpture of the sides of the alitrunk, which is evenly and completely punctulate and opaque, or nearly so, in all the species thus far known. Other characters, most of which will not hold in one or more species, are the following:

- (1) Habitus of the "normal" *Smithistruma* sort, body slightly to moderately depressed and rather compact.
- (2) Mandibles with the usual dentition; basal lamella broadly triangular, with either rounded or angular apex; no toothless diastema present. Blades rather strongly depressed.
- (3) Antennal scapes depressed and incrassate, the anterior border sharp and broadly rounded. Funicular segment III very short, usually transverse.
- (4) Postpetiolar disc most often punctulate and opaque or subopaque.
- (5) Spongiform appendages in most species drastically reduced, absent or vestigial on the petiole except in *epinotalis*.
- (6) Pilosity short, spatulate or spoon-shaped; gastric dorsum with con-



spicuous, obliquely erect hairs, moderate in length and with thickened or flattened apices. Specialized erect hairs of head and alitrunk absent or relatively poorly differentiated and not well developed in most species.

In most of the species, the eyes are rather large and coarsely faceted compared with other *Smithistruma*. This ocular development is apparently correlated with the mode of life, for the majority of the species appear to choose arboreal or subarboreal nest sites. Where the nest sites have been recorded, in all species of the group except the aberrant *margaritae*, the colonies were found in plant cavities such as orchid pseudobulbs, spaces within other epiphytes like *Tillandsia*, under bark of standing trees, in the spatha of an aroid vine, etc., etc. Two of the species are known only from specimens intercepted in plant quarantine on epiphytic orchids originating in northern South America. The finding of several new species of *Strumigenys* in the same circumstances shows that there must be a very large arboreal fauna of dacetines as yet virtually unknown in the Neotropical Region. *Strumigenys rehi* Forel and *S. tocoae* Wheeler are probably Amazonian representatives of this fauna. Indications that the same situation applies in the Indo-Papuan and Ethiopian Regions are furnished by series in my working collections as yet unreported upon. In order that an arboreal fauna of *Strumigenys* complex species may maintain itself, a rich fauna of collembolans is probably necessary in the same habitat. If this is so, then it would seem that mossy, epiphyte-laden cloud- or rain-forest is the best place to look for arboreal dacetines. In cloud-forests, the limit between the vegetation of the ground and that clinging to the trees is often so indefinite as to be merely academic, so that many "arboreal" species in such an environment may live either on the ground or in the trees proper.

The species of the *schulzi* group as outlined below are often differentiated on relatively minor characteristics of size, proportion, color, sculpture, pilosity, etc., but in the few species which are known from several collections these characters seem to hold constant. Much more collecting will be needed to determine whether this degree of constant variation holds throughout the group. Furthermore, it is necessary, in view of the closeness of the species and the ambiguity of the original descriptions, that *emiliae* and *schulzi* be redescribed more thoroughly and with measurements that can be confidently compared to those given below.

SMITHISTRUMA (SMITHISTRUMA) EPINOTALIS (Weber)

Pl. II, fig. 23

*Strumigenys* (*Cephaloxys*) *studiosi* subsp. *epinotalis* Weber, 1934: April, Revista de Ent. 4:46, worker, female. *Strumigenys* (*Cephaloxys*) *skwarrae* Wheeler, 1934: November, Bull. Mus. Comp. Zool. Harvard 87:177-178, worker. Skwarra, 1934, Ökologische Studien über Ameisen und Ameisenpflanzen in Mexico. R. Leupold, Königsberg (private printing), ecology. (new syn.)

*Worker*: TL 1.88-2.11, HL 0.48-0.53, WL 0.49-0.60, CI 77-80, MI 22-24. Measurements from 30 workers, including a nidotype of *epinotalis* and cotypes of *skwarrae*, and representing at least 7 separate colonies from Mexico and Costa Rica, including size extremes selected during a rough examination of about 150 specimens.

With general characters of the *schulzi* group, except as noted. Posterior occipital excision semicircular, moderate in width. Preocular laminae approximately straight, distinctly converging anteriorly. Clypeus weakly subpentagonal, the anterolateral corners rounded and indistinct. Anterior clypeal border convex, with a narrow, indistinctly depressed apron. In a specimen with HL 0.53, the exposed length of the scape is 0.26 mm., of

funiculus, 0.40 mm. The scape is incrassate, but not so strongly as in *studiosi*; anterior border evenly rounded. Funicular segments: IV slightly longer than I; II + III shorter than I; II not longer than broad, but longer than III; III broader than long; V very slightly longer than I-IV taken together. Mandibles depressed, only weakly deflected apically; dentition as in fig. 23.

Anterior pronotal border sharp, semicircularly curved; humeral angles not developed. Pronotal dorsum with a curved, blunt transverse ridge, behind which is a faint promesonotal sulcus. Metanotal groove indistinct. Seen from the side, the dorsal alitrunkal profile is evenly and gently convex without distinct interruption. Propodeal teeth acute, slightly elevated, almost entirely involved in the broad, convex infradental lamellae. Petiolar node broader than long, with a sloping anterior face; summit narrowly rounded seen from the side. Petiolar spongiform tissues more strongly developed than in any other known *schulzi* group member, but not so strongly as in the Nearctic groups. Posterior transverse collar rather well developed, forming blunt posterolateral lobes. Midventral strip quite distinct and of moderate width. Postpetiolar disc convex, very nearly or quite completely smooth and definitely shining. Postpetiolar appendages well developed, but not covering anterolateral surfaces of the node. Gaster with anterodorsal transverse spongiform margin and anteroventral pad. Basal gastric costulae distinct, with fine indistinct intercalary striation, extending  $1/4$  to  $1/3$  the length of the first gastric tergite.

Sides of alitrunk completely and densely punctulate and opaque in most specimens; a few individuals with a restricted area at the anteroventral corner of the mesepisternum having punctulation more or less effaced and smooth.

Cephalic ground pilosity composed of numerous small, crowded spoon-shaped hairs bent strongly mesad. Erect hairs of occipital region only weakly differentiated from the ground pilosity and not very long. Hairs on anterior scape border spoon-shaped, usually 8 in number, largest and broadest nearest base. Clypeus with very small subappressed spatulate hairs on discal surface; free border with 7-8 short, crowded, mesially curved spatulate hairs. Dorsum of alitrunk with relatively few small but conspicuous curved or curled, broadly spoon-shaped hairs, mostly concentrated along the semicircular ridge in front of the promesonotal sulcus; a few of these hairs also on the mesonotum; all or nearly all of the alitrunkal hairs bent toward the midline. No long differentiated paired humeral or other erect hairs. Nodes and gaster with the usual obliquely erect spatulate hairs of the *schulzi* group.

Color yellowish- to medium ferrugineous, gaster usually darker than thorax. In darker specimens, the head may also be very faintly darkened above.

*Female:* TL 2.15, HL 0.56, WL 0.64, CI 79, MI 23. Mesonotum densely punctulate, without median carinula or rugulation, but with 6 pairs of erect hairs with weakly enlarged apices in addition to the ground pilosity. Dorsum of gaster posteriorly with scattered, small, inconspicuous appressed simple hairs in addition to the spatulate erect ones. Punctulation of anterior mesanepisternum and center of mesokatepisternum effaced; these areas smooth and shining. Color as in darker workers; gaster reddish-brown. Weber recorded the length of the gynotype female as 2.3 mm., and his measurements of this species correspond in general with my own. The description here is taken from a dealate queen in the colony from El Palmar (see below).

*Material examined:* One nidotypic worker kindly sent by Dr. G. C. Wheeler. Worker cotypes and gynotype in Weber Coll.; I was not able to see any of the actual cotypes due to Dr. Weber's absence in the Arctic at the time I was studying this group.

*Type locality:* Talia Farm, Estrella Valley, Costa Rica (G. C. Wheeler; No. 29).

A small series of workers from Estrella Valley, Costa Rica (W. M. Mann).

Several series of workers making up the cotype series of *S. skwarrae* Wheeler [MCZ, USNM, etc.] collected by Elizabeth Skwarra at Tlacocinctla (*skwarrae* type locality) and Mirador, Vera Cruz, Mexico. Miss Skwarra's collections were made chiefly in the epiphyte *Tillandsia streptophylla*, where she found nests containing 250-300 workers. Stray workers were also found in other plant cavities (loc. cit.).

A colony, thought to be nearly complete, containing about 110 workers and 3 dealate females, nesting in the spathe of an aroid vine growing against a tree trunk a few feet above the ground at El Palmar, 16 km. west of Tetzipana, Vera Cruz, Mexico (F. G. Werner). This locality lies at some 600 feet in altitude and is a jungle area with rubber and coffee plantations.

*S. epinotalis* is apparently a common species in southern Mexico and much of Central

America. It is somewhat intermediate between the "typical" members of the *schulzi* group and other New World *Smithistruma* species in sculpture and development of the spongiform appendages and infradental lamellae. A good distinguishing character is the arcuate "secondary margin" of the pronotum, made conspicuous by the rather isolated band of squat, whitish spoon-shaped hairs it bears.

*Smithistruma (Smithistruma) alegrensis* new species

Pl. II, fig. 22

*Holotype worker*: TL 1.95, HL 0.50, WL 0.48, CI 79, MI 20, ICD 52. Habitus of *schulzi* group, but with evenly rounded free clypeal border and shining postpetiolar dorsum. Head broad and thick; including mandibles, triangular; posterior excision moderate; preocular laminae feebly convex, decidedly convergent and passing in one continuous line to the tips of the closed mandibles on each side. Eyes at about the midlength of the head, oval with about 5 facets in the greatest diameter, not protruding at the sides when the head is viewed from a directly dorsal position. Viewed from the side, the dorsal cephalic outline is feebly convex anterior to vertex with a very weak depression just posterior to the clypeus. Median region of verticociput with a very superficial impression. Clypeus only weakly convex, a very narrow depressed apron or margin along the anterior part of the free border; the latter broadly and continuously rounded, without distinct traces of anterolateral angulation. Posterior clypeal border forming a blunt right angle, the border itself distinct. Mandibles weakly depressed and broadened, the blades converging to a rather bluntly rounded apex at full closure; in lateral view, this truncate appearance is seen to be caused by the strong deflection of the tips of the mandibles at almost a right angle. For mandibular shape and dentition, see fig. 22.

Normally exposed portion of antennal scape about 0.24 mm. long, evenly curved at the basal third (angle  $35^{\circ}$ - $40^{\circ}$ ), with broadly rounded anterior border; incassate, but not so strongly as in *schulzi*, *orchibia*, *studiosi*, etc. Funiculus 0.40 mm. long; apical segment making up slightly more than  $1/2$  the total length; segment I slightly longer than IV; II about as broad as long; III shorter, transverse; II + III shorter than IV.

Alitrunk slightly depressed, resembling that of *margaritae*, with a continuous, gently convex dorsum not interrupted by metanotal groove; the latter present only as a dark line seen in dorsal view. Propodeal dorsum distinctly broader than long. Propodeal teeth slender, compressed, acute, elevated and divergent, about  $3/5$  as long as the distance between the centers of their bases. Infradental lamellae narrow, thin, areolated and slightly convex and broadened near their ventral ends. Petiolar node approximately as long as or very slightly shorter than its peduncle; anterior nodal face sloping; posterodorsal nodal face about  $2/3$  as long as broad, with a straight anterior edge and slightly concave sides. Ventral petiolar spongiform appendages present only as extremely fine vestiges; posterior transverse collar narrow, broadening somewhat at the sides to form moderate rounded lobes. Postpetiole transversely elliptical  $3/5$  as long as broad, convex dorsally, the free dorsal surface not punctulate, but very feebly, loosely and indefinitely longitudinally substriate, more or less shining, especially in the middle; appendages moderately well developed, but the anterior sides free and the posterodorsal isthmus broken in the middle. Gaster with a fairly well developed anteroventral pad and a fine subspongiform anterodorsal margin. Gastric costulae distinct, parallel, but only about  $1/5$  the length of the basal gastric tergite; remainder of the gaster smooth and shining, with scattered indistinct punctures. Sculpture otherwise as in typical *schulzi* group members, the head, alitrunk and petiole densely punctulate and opaque throughout.

Cephalic pilosity consisting entirely of broadly spoon-shaped hairs, larger and more distinct than in *orchibia*, *studiosi*, etc., the broadened portions bent so as to closely parallel the supporting surface, directed toward the midline. Hairs on clypeal disc very small, spatulate, subappressed; those on the free border larger, linear-spatulate, about 6 on each side of the center, weakly curved medially. Hairs on anterior scape border 8 in number, all except the two small ones at the apex broadly spoon-shaped. Hairs of alitrunk like those of head, but fewer; a hair on each humerus is slightly larger than those around it, but is subreclinate and not really differentiated. Hairs on nodes and gaster conspicuous (on gastric dorsum .05 to .07 mm. long), spatulate, inclined posteriorly; placed 4 on petiolar node, 8 on postpetiolar node, 6 or 7 transverse, irregular rows of about 4 each on the basal gastric tergite and a single row of 4 smaller, finer hairs on each of the succeeding exposed segments.

Color pale ferrugineous yellow.

Holotype selected from a series of 14 workers (13 are paratypes) from Porto Alegre, Rio Grande do Sul, Brazil (P. Buck). The holotypes and several paratypes are to be returned to the collection of Father Thomaz Borgmeier; two of the 14 specimens (paratypes) were received through Sr. Mario Consani, and will be returned to his collection. All of the specimens examined apparently came originally from the same nest.

*Paratypes:* 13 specimens with the same data as for the holotype. TL 1.90-2.06, HL 0.50-0.52, WL 0.47-0.54, CI 76-81, MI 18-22. Mandibular dentition constant in three specimens dissected. Pale to medium ferrugineous yellow. In addition to the dispositions listed above, paratypes have been placed in the MCZ, USNM, ANS. Male and female unknown.

Apparently closely related to *emiliae*, but the postpetiolar sculpture and possibly also the mandibular dentition distinctive.

#### SMITHISTRUMA (SMITHISTRUMA) EMILIAE (Forel)

*Strumigenys emiliae* Forel, 1907, Ann. Mus. Nat. Hung. 5:11-12, worker. *Strumigenys* (*Cephaloxys*) *emiliae* Emery, 1922, Gen. Ins. Fasc. 174:325.

*Worker:* Forel's description leaves little doubt about the group to which this species belongs, since he mentions the entirely punctulate body, with only the gaster smooth and shining. He also specifically mentions that spongiform appendages are present on both nodes, but "not under the peduncle of the petiole." Although he places the species in the *baudueri* group, he also states, "... related to *margaritae*, but distinguished by its wider head and shining abdomen." He gives the length as "1.8 mm.," but considering his other measurements against known specimens, we should probably consider the length in terms of the TL used here as about 2.0 mm. Following are some excerpts from Forel's original description considered to be significant for the present purposes, adapted to the present terminology:

"Mandibles shorter than clypeus. Clypeus slightly wider than long, with arcuate anterior border. Eyes at midlength of head, not visible from dorsal view. Alitrunk very feebly convex; promesonotal suture indistinct; metanotal groove distinct; dorsal profile continuous. Pronotum laterally submarginate; mesonotum and propodeum marginate. Dorsal face of propodeum subquadrate, as broad as long, slightly narrowed posteriorly. Propodeal teeth almost horizontal, distinctly divergent, acute, slender,  $\frac{3}{4}$  as long as the space between their bases. Infradental lamellae small, areolate. Petiolar node low, short, much wider than long, convex behind, truncate anteriorly; peduncle at least twice the length of the node. Postpetiolar node almost twice the width of the petiolar node.

"Densely reticulate-punctulate, opaque, including scapes and propodeal declivity. Gaster smooth and shining; short longitudinal costulae at base. Brilliant sessile spoon-shaped hairs dispersed quite regularly over head and thorax; on scapes and free clypeal border more nearly pedunculate. Legs and gaster with long-pedunculate, less broadened hairs, erect on gaster, grading into ordinary appressed and subappressed hairs also dispersed over body and limbs. No erect hairs on tibiae.

"Entirely dull yellowish-testaceous, a little darker on head and alitrunk."

Type presumably in the Hungarian National Museum. Male and female unknown. *Type locality:* Asunción, Paraguay (Vezényi).

I have not been able to examine specimens of this ant, which seems from the description to be related to the species just described as *alegrensis*.

#### SMITHISTRUMA (SMITHISTRUMA) STUDIOSI (Weber)

*Strumigenys* (*Cephaloxys*) *studiosi* Weber, 1934, Revista de Ent. 4:44-45, fig. 5, worker.

*Worker:* Weber's original surmise that this ant is closely related to *margaritae* was correct; however, it is even more closely related to *schulzi*, *orchibia*, and other more "typical" members of the *schulzi* group. I have seen a single worker from the type nest through the courtesy of Dr. G. C. Wheeler, and the measurements and proportions are taken from this specimen: TL 1.97 (Weber states that the total length of the type series is 1.9 to 2.1, and his measurements are usually quite accurate), HL 0.52, WL 0.52, CI 77, MI 18, ICD 50. Except for size, color and relative head width closely similar to *orchibia*, the next species described below, although the eyes in *studiosi* are not visible from a position directly dorsal to the head (in my specimen). Weber's figure shows the eyes rather

prominently protruding at the sides; in my specimen, the eyes are smaller, with only about five facets in the greatest diameter; this may be due to normal variation within one nest series. This single nidotype differs from Weber's figure (as do most other *schulzi* group species) in having the clypeus more nearly subpentagonal, with a more transverse anterior border. Compared with my specimen, Weber's figure shows longer, more slender and more crooked hairs fringing the occipital lobes, and the hairs of his clypeal fringe seem to be too narrow.

*Studiosi* is smaller and more slender throughout relative to the total length than is *orchibia*, and the metanotal groove is even less distinct. The two small hairs on the anterior angles of the petiolar node are erect. The basal gastric costulae are interspersed with fine striae like those of *orchibia*, running longitudinally and occupying about 1/3 of the basal gastric tergite. Posterior to the striated area, the basal tergite is very superficially and irregularly shagreened throughout, with scattered shallow punctulae. This sculpture appears almost like a secretion instead of a true integumental feature, but since Weber also mentions it for his five cotype specimens, it may possibly be reckoned as a constant and permanent character. The posterior half of the segment is weakly but distinctly shining in spite of the shagreening, which is rather patchy in its concentration in any case.

Infradental lamellae of propodeum slightly wider and more convex below than in *orchibia*; postpetiolar node almost twice as broad as long. Color ferrugineous yellow, the thorax a bit lighter than the head and gaster.

Other than those mentioned, I can detect no differences of perceptible degree between *studiosi* and *orchibia*. The pilosity, petiolar proportions and development of spongiform appendages closely similar. The mandibles have not been dissected, and these may show additional differences between the two forms. Male and female unknown.

Types are in the collection of Dr. N. A. Weber. *Type locality*: Sixaola River, Limon Province, Costa Rica (G. C. Wheeler). No other collections are known to me.

#### Smithistruma (Smithistruma) *orchibia* new species

Pl. II, fig. 24

*Holotype worker*: TL 2.28, HL 0.60, WL 0.60, CI 71, MI 17, ICD 47. With the general characters of the *schulzi* group, in which it is the largest and one of the most deeply pigmented members. Dorsal cephalic profile straight from vertex to posterior clypeal angle, the latter slightly raised. Eyes at the midlength of the head, distinctly protruding at the sides in full face view of head, only moderately convex, each with about 6 facets in its greatest diameter, oval in shape. Preocular laminae straight and approximately parallel. Clypeus of the usual subpentagonal shape; anterolateral angles bluntly rounded and anterior border transverse and straight; posterior angle blunt. Clypeal surface nearly plane, weakly raised in the center to the small suboval tumulus. The shining tumular surface may be seen just posterior to the center of the anterior border; at the level of its posterior section, a dark, weakly arcuate transverse line connects the two lateral clypeal angles and marks the posterior border of the weakly differentiated anterior apron.

Mandibles broad and strong, somewhat depressed, only very feebly arched and the tips only very weakly deflected ventrad; at full closure, the lateral borders continue the outline of the sides of the clypeus. Dentition as in figure 24. Antennal scape as normally exposed 0.26 mm. long, broadly incrassate, the greatest breadth at about the basal third, gently curved near base; anterior border lamelliform, cultrate, strongly convex, ending in a small subangular apical process. Posterior scape border gently concave at basal bend, beyond this nearly straight. Funiculus about 0.42 mm. long; apical segment 0.25 mm. long; segment I slightly longer than IV, but much more slender; IV about equal to II + III; II slightly longer than broad; III broader than long.

Pronotum depressed, only feebly convex, anterior border marginate and broadly rounded, without humeral angles or median carinula, but feebly submarginate along the sides. Mesonotum virtually indistinguishably fused with the pronotum, the suture extremely indistinct. Mesonotum gently convex and in profile virtually continuous with the feebly convex propodeal dorsum, only a very feeble dip occurring at the shallow, obsolescent metanotal groove. Propodeal teeth stout, triangular, about 2/3 as long as the distance between the centers of their bases, weakly divergent. Infradental lamellae thick and fairly broad, but rather deeply excised just below the teeth.

Petiolar node large and heavy, slightly longer than its peduncle, subquadrate both in dorsal and lateral views; seen from above, the free dorsal face about  $5/6$  as long as broad, very nearly as long as is the free postpetiolar disc; sides convex and anterolateral angles rounded. Posterior transverse spongiform collar of petiolar node poorly developed, slightly widened at sides; ventral band represented by a very minute posterior vestige. Postpetiole subreniform, anterior border straight and posterior border with the usual weak median emargination; most of lateral surfaces free of spongiform tissue, strongly convex; transverse posterior band only moderately well developed and very tenuous in the center; ventral lobes fairly well developed. Gaster convex above, with moderately well developed anterodorsal spongiform border. Basal costulae very fine and numerous, giving the effect of fine, regular striolation taking up nearly the entire anterior half of the basal tergites. This striolation has bilateral origins along the anterior border, the more median elements curving inward to form a complete arch with similar elements of the other side (compare with paratype variation), while the more lateral striation continues posteriad. Posterior half of basal tergite and remainder of gaster smooth and shining, with scattered piligerous punctures. Rest of body, except weakly shining mandibles and funiculi, densely punctulate-granulose and opaque.

Ground pilosity of head and clypeus consisting of numerous but small and separated subappressed spatulate hairs, directed anteriorly and often a trifle obliquely away from the midline. Clypeal border with a fringe of larger, more nearly spoon-shaped hairs, 9 on each side of the midline, those on the anterior border smaller than those on the sides. 8 hairs on anterior scape border; nos. 1-5 broadly spatulate; 1, 2, 7, 8 directed apicad, the rest directed basad. A rather prominent spoon-shaped hair, bent anteriorly, on each dorsal scrobe border a little posterior to the level of the eyes. Alitrunk with a very few small, quite inconspicuous appressed and subappressed spatulate hairs. One or two small, narrow subappressed spatulate hairs on each side of the declivity of the petiolar node. In addition, a number of short, stout erect spatulate or clavate hairs occur in definite positions: a transverse row of 4 on the posterior occiput, one on each lateral occipital border at the end of the scrobe, one each on the paired low humeral and mesonotal tubercles, a pair on the posterior dorsum of the petiolar node, 6 (small) on the postpetiolar dorsum, and about 18 scattered rather evenly over the basal gastric tergite. These hairs vary in length from about 0.3 to 0.7 mm. Apical segments of gaster with a few smaller, more slender, erect clavate and subclavate hairs.

Color deep orange-brown; legs, mandibles and antennae a bit lighter and more yellowish.

Holotype [USNM] taken in U. S. Plant Quarantine at San Francisco from an orchid plant, *Cattleya mossiae*, shipped from Caracas, Venezuela, the exact locality of collection unknown. Label with quarantine no. SF 20295.

Paratypes: 28 workers with the same data as for the holotype, and apparently of the same nest. TL 2.16-2.37, HL 0.60-0.63, WL 0.60-0.65, CI 70-73, MI 16-17. Slight variation in size of propodeal teeth and lamellar excision. Erect hairs of postpetiole 6-8, of basal gastric tergite, 16-20. Basal striolation of gaster highly variable in direction, many individuals differing from the holotype in that the striolae are not bilaterally grouped and not arched, but instead are straight and parallel as in other *Smithistruma* species. In all specimens, however, the same extraordinary fineness of this sculpture holds constant, as does the amount of space it takes up on the first tergite of the gaster. Color variation very slight; a few individuals show slight infuscation of the dorsum of the head. Paratypes in USNM, MCZ, etc. Female unknown.

Allotype male: TL (omitting extruded genital capsule) 2.38, HL 0.47, WL 0.68, CI 76, full length of a mandible 0.13 mm., greatest diameter of eye 0.19 mm., distance from anterior ocular border to mandibular insertion 0.7 mm. In direct dorsal view, posterior occipital border straight. Clypeus convex in both directions, with a narrow, slightly depressed apron along the free border. Cephalic dorsum with a feeble median furrow running from anterior ocellus to a point just posterior to the level of the antennal insertions. Mandibles subfalcate, narrow, the apparent basal and apical borders meeting very close to the apex in a distinct subdentiform angle, the apical border therefore very short and weakly concave; at moderate magnifications, this set of circumstances causes the apex of the mandible to appear obliquely truncate.

Alitrunk robust, humped; mesonotum convex, notauli fairly distinct anterolaterally, but indistinct at their point of juncture; parapsidal furrows distinct; scutellum convex.



Prescutum with a feeble median furrow; scutum without carinula or striation. Petiolar node low, with a gradually sloping anterior face. Ventral longitudinal spongiform band of petiole present as a straight, even, whitish ribbon, narrow but distinct; posterior collar reduced to two tiny posterolateral vestiges. Postpetiole about twice as broad as long, slightly shorter than petiolar node, but much broader. Postpetiolar spongiform masses as in worker, except that the posterior transverse band and its lateral extensions are not so well developed. Propodeal teeth very small, but fairly acute; infradental lamellae very narrow.

Both nodes, entire gaster, and greater part of the sides of the alitrunk smooth and shining; remainder of body densely punctulate. Thorax, antennae and nodes deep yellowish-brown, the upper part of the alitrunk, especially the parapsidal furrows, infuscated; head brownish-black, the clypeus lighter ferruginous anteriorly; gaster castaneous; legs, mandibles and genitalia dull yellow.

Forewing about 2.0 mm. long; veins  $R + Sc$ , stigma,  $Rsf_1$ ,  $Mf_1$ ,  $M + Cu$ ,  $CuA$ , and  $2r$  clearly defined and well pigmented;  $Rs + Rs + M$  very weak, scarcely pigmented. Volsella of genitalia quite constant in 3 males dissected (alloparatypes); shape very similar to the figure given by Weber for *Smithistruma* (*Platysurma*) *depressiceps* in his 1934 paper (fig. 14c). The alloparatypes number 18 individuals, taken with the allotype and holotype from the same orchid plant. TL 2.32-2.61; color often deeper than in allotype, the dorsum of the alitrunk sometimes entirely blackish-brown. Most of the specimens had the genitalic capsules almost wholly extruded, but closed, adding an average of 0.25 mm. to the measurements as given. Allotype in USNM; alloparatypes distributed as the paratypes.

#### *Smithistruma* (*Smithistruma*) *castanea* new species

*Holotype worker*: TL 1.91, HL 0.52, WL 0.53, CI 77, MI 15, ICD 46. Very close to both *orchibia* and *studiosi*, the color more as in the former and the size and head more as in the latter. Occipital excision broad and rather shallow. Preocular laminae feebly convex, slightly converging. Eyes each with about 7 facets in the greatest diameter, not visibly protruding when the head is seen from a directly dorsal view. Dorsal outline of head in profile weakly convex between vertex and posterior clypeal angle. Clypeus only very slightly broader than long; shape as in *orchibia* except that the anterior border is extremely shallowly, almost imperceptibly concave when viewed from a directly dorsal position. Antennal scape 0.22 mm. long, funiculus 0.38 mm. long; antennae entirely similar to those of *orchibia* and *studiosi*, except that the scape seems to be a trifle more incassate than in either of these species.

Alitrunk as in the two related species, the metanotal groove scarcely interrupting the continuous, gently convex dorsal profile. Propodeal teeth rather large, nearly as long as the distance between the centers of their bases; infradental lamellae continuous with teeth, but receding, causing the teeth to be broadly triangular. More ventrally, the lamellae are of moderate and even width, following the concave declivity, not enlarged at ventral extremities. Petiole as in *orchibia*, the node truncate anteriorly, scarcely broader than long, as long as the postpetiolar node; the latter subreniform, approximately twice as broad as long. Ventral spongiform appendages of petiole completely lacking; posterior collar reduced to a very narrow vestige without enlargement of lateral lobes. Postpetiolar appendages similar to those of *orchibia*, but slightly reduced in size.

Sculpture as in *studiosi* and *orchibia* except for gaster; basal costulae fewer and more irregular, with some very indistinct striations between, running longitudinally and occupying not more than the basal  $\frac{1}{4}$  of the first gastric tergite. Remainder of gaster smooth and shining.

Ground pilosity of upper cephalic dorsum distinctive; hairs small, distinctly inverted-spoon-shaped, each raised on a short but nearly vertical peduncle, the broadened portion bent so as to parallel the integumental surface and directed obliquely toward the cephalic midline. The hairs are slightly larger and fewer and not so nearly appressed as in the two close relatives, and the direction of the pilosity on the head is immediately distinctive when the three forms are compared. Special erect hairs and fringes of scapes and free clypeal border much as in *orchibia*.

Color dark reddish brown, the head and gaster slightly darker than the alitrunk; legs, mandibles and antennae ferruginous yellow.

Holotype one of five workers intercepted in U. S. Plant Quarantine, No. EQA



432835, bearing also the following data: "Colombia, 10-1-37. On orchid pseudobulb." Deposited in USNM.

*Paratypes:* The remaining 4 workers taken with the holotype. TL 1.86-2.11, HL 0.52-0.55, WL 0.53-0.56, CI 75-77, MI 15-17. Color in 2 individuals slightly lighter than in holotype, more as in *orchibia*, but alitrunk still usually lighter than head and thorax. Basal gastric costulae 1/4 to 1/3 the length of the basal gastric tergite. Deposited in USNM and MCZ. Male and female unknown.

#### SMITHISTRUMA (SMITHISTRUMA) SCHULZI (Emery)

*Strumigenys schulzi* Emery, 1894, Bull. Soc. Ent. Ital. 26:213-214, Pl. 1, fig. 7, worker. *Strumigenys schulzi* Wheeler, 1908, Bull. Amer. Mus. Nat. Hist. 24:148, worker, in key. ? Mann, 1916, Bull. Mus. Comp. Zool. Harvard 60:453. *Strumigenys* (*Cephaloxys*) *schulzi* Emery, 1922, Gen. Ins. Fasc. 174:325.

*Worker:* Emery's diagnosis of this ant consists of a short absolute description in Latin, a comparison in Italian against *margaritae*, and an extremely sketchy figure. This adds up to a fair characterization, but one which requires supplementation because of the very close new species described since. I have selected points from Emery's diagnosis which seem significant, adapting them to the terminology used here.

The length is given as "1½ mm." Since Emery's measurements are usually slightly under those I give as TL for other dacetina species, a probable TL for *schulzi* might be about 1.65-1.75 mm. From the figure, which is very crude, one might expect that the CI would be close to 80. Occipital lobes bulging laterally and broadly rounded; preocular laminae converging. Clypeus much as in *orchibia*, as is also the degree of incrassation of the scapes. Funicular segments II, III, and IV are described and figured as transverse, or not longer than broad.

*Schulzi* is stated to differ from *margaritae* in smaller size, shorter, more robust head and alitrunk, broader scapes, smaller propodeal teeth, presence of moderate infradental lamellae, presence of vestigial posterior petiolar spongiform collar and moderately well developed lateral and ventral spongiform appendages on the postpetiole. Basal gastric tergite "smooth and shining posteriorly; opaque, punctulate, and with a few striae anteriorly. Curved hairs of head a little better developed than in *margaritae*." Color testaceous; head, alitrunk and both nodes opaque.

Female and male undescribed. *Type locality:* Pará (Belem) Brazil (A. Schulz), "under bark of a tree." Types in Emery Coll.

Mann determined as this species some specimens taken at the type locality, but these specimens are not presently in the collections of either the USNM or the MCZ.

A light ferrugineous specimen taken by F. Nevermann at Hamburg Farm, Santa Clara Prov., Costa Rica, agrees well with the supposed *schulzi* dimensions and other characters, but the head is narrower and the proportions of the funicular segments are not quite as described by Emery: TL 1.75, HL 0.50, WL 0.48, CI 73, MI 11. The color is light ferrugineous yellow. Probably this form merits description as a new species, but I have accidentally broken the gaster off in examining it. In view of the closeness of *schulzi*, more material should be gathered before characterizing any such forms.

#### SMITHISTRUMA (SMITHISTRUMA) MARGARITAE (Forel)

Pl. II, fig. 20

*Strumigenys margaritae* Forel, 1893, Trans. Ent. Soc. Lond. p. 378, worker, female, male. *Strumigenys margaritae* Emery, 1894, Bull. Soc. Ent. Ital. Pl. 1, fig. 6, worker. Wheeler, 1908, Bull. Amer. Mus. Nat. Hist. 24:148, worker, in key. Forel, 1912, Mem. Soc. Ent. Belg. 19:198. Mann, 1920, Bull. Amer. Mus. Nat. Hist. 42:430. *Strumigenys* (*Cephaloxys*) *margaritae* Emery, 1922, Gen. Ins. Fasc. 174:325. M. R. Smith, 1931, Ann. Ent. Soc. Amer. 24:692-693, Pl. 2, fig. 7, worker. *Strumigenys* (*Trichoscapa*) *margaritae* M. R. Smith, 1947, Amer. Midl. Nat. 37:587.

*Worker:* TL 2.01-2.18, HL 0.53-0.58, WL 0.53-0.56, CI 69-73, MI 17-20, ICD 50-52. Measurements taken from 23 workers, representing at least 7 different colonies and including a cotype and representatives from localities in the West Indies and the south-eastern United States.

Although known for a longer time and quite common in many parts of its range, *margaritae* is a rather atypical member of the *schulzi* group. Both Emery's and Smith's

figures show the head shape fairly well, though the anterolateral angles of the clypeus in Smith's figure and the mandibles in Emery's figure are shown differently from those of specimens before me, which include not only the West Indian and North American material measured, but also specimens from Colombia and southern Mexico. Emery's representation of the clypeal shape and the antennal scapes appears more realistic, though crudely drawn, than does that of Smith. Neither figure shows the mandibular dentition anywhere near correctly, and since this is an important character, I have depicted it in fig. 20. The pilosity in Smith's figure is rather good, although my specimens seem to have the individual hairs smaller and more abundant. Six specimens from Texas, Chiapas, and the Lesser Antilles show exactly the same mandibular dentition and pilosity. Eyes as in Smith's and Emery's figures, distinctly protruding at the sides in dorsal view of head; antennal scrobes shallow and poorly defined. The hairs of the alitrunk are similar to those of the head, but longer and less abundant. Alitrunk without definite humeral angles; dorsal profile continuous, gently convex; metanotal groove weakly depressed, seen as a fine dark line from dorsal view. Propodeal teeth nearly or quite as long as the distance between the centers of their bases, compressed-spiniform, slightly elevated and diverging. Infradental lamellae reduced to fine cariniform ridges.

Petiolar node approximately as long as its peduncle, seen from above, considerably broader than long, with a sloping anterior face. Postpetiolar node convex and about twice as broad as long, more than half again as broad as the petiolar node. Petiolar spongiform appendage reduced to the merest vestige of a posterior collar. Postpetiolar appendage reduced to a rather small ventral mass and a posterior transverse belt of moderate width, the latter not broken in the middle. Anteroventral pad of gaster vestigial.

The basal gastric costulae are not lacking, but are small and short, not so evident as in some related species. The gastric surface both dorsally and ventrally is sculptured differently from all other *Smithistruma*, but in much the same way as some *Strumigenys* species like *louisianae*, etc. The gastric sculpture is basically composed of very small, densely packed shallow punctures, on the first tergite with distinct but very fine longitudinal superimposed striolation. Except for certain insignificant highlights reflected from the minute elements of this sculpture, the surface may be said to be totally opaque. Head, alitrunk, legs, antennae and nodes densely punctulate and opaque.

Numerous small, subappressed spatulate hairs on head and alitrunk, directed mesially. Longer spatulate hairs of nodes and gastric dorsum rather numerous, obliquely inclined posteriorly. The only really erect hairs on the body are two forming a pair, one arising perpendicularly on each side just lateral to the infradental lamella near its midlength; these small hairs narrowly spatulate and feebly curved. Color ferruginous yellow.

*Female*, dealate: The females of this species differ somewhat from the workers in general habitus and also vary more than is usual among themselves. Two specimens from Alabama are here recorded separately: Gulf State Park, Baldwin Co. (E. O. Wilson), TL 2.48, HL 0.60, WL 0.64, CI 64, MI 20, ICD 63. Bryce Lake, Tuscaloosa Co., TL 2.85, HL 0.64, WL 0.74, CI 68, MI 22, ICD 60. The convexity of the vertex is very marked, and the posterior excision is very shallow, appearing almost straight in directly dorsal view. Antennal scapes slightly broader than those of the worker and more angulate basally; mandibles relatively more massive. Hairs on occiput longer, some often suberect, and many of those on the mesonotum suberect and posteriorly inclined. The propodeal teeth may have apices ventrally deflected at their apices, or may be straight. The Bryce Lake specimen has the mesokatepisternum smooth and shining, while in other females, the sides of the alitrunk may be punctulate and opaque throughout. The gaster, while densely and shallowly punctulate throughout, lacks the striation seen in the worker. Color yellowish to medium ferruginous; ocellar area variably, but usually deeply infuscated.

*Male*: Described by Forel; none seen during the course of the present work. Types of all castes are in the Forel Coll., and worker types are also in various North American and European Museums. The cotype in the MCZ is designated as *lectotype*, designation present.

*Type locality*: St. Vincent, B. W. I. (H. H. Smith).

*Material examined*: One cotype worker and small series from the following localities: Antigua and Montserrat, B. W. I. (N. A. Weber). Nassau, Bahamas Is. (W. M.

Mann). Mobile, Baldwin and Tuscaloosa counties, Alabama (E. O. Wilson). Comal Co., Texas (C. F. Baker). New Braunfels, Texas (W. M. Wheeler). Palenque Ruins, Chiapas, Mexico (C. J. Goodnight). Rio Porco, Colombia, 1020 M. (N. A. Weber).

*Remarks:* Forel has also recorded this species from Martinique. Dr. M. R. Smith has suggested that it may occur as a tramp species in the U. S. This is also my own opinion, but it is possible that *margaritae* had a circum-Caribbean distribution even in pre-Columbian times. The affinities are quite certainly with the Neotropical *schulzi* group, and not with any Nearctic form.

According to H. H. Smith (in Forel, loc. cit. 1893), *margaritae* is a rather common ant on St. Vincent, usually nesting in the sod layers covering rocks. The colonies at this locality were estimated to contain up to 250 individuals. One of the nests was taken in an open place at the foot of a tree. In Alabama, Mr. Wilson took the two solitary dealate females already mentioned in October and November, and also captured a stray worker from leaf litter. Dr. Goodnight found this species in soil samples in Chiapas. Thus it appears that *margaritae* does not share the arboreal tendencies shown by the other members of the *schulzi* group, in spite of the large, protruding eyes and other characters which would seem to fit it for life in epiphytes. *Margaritae* is easily recognized by its finely but distinctly and entirely sculptured gaster and by the extreme reduction of its infradental lamellae.

#### ORNATA GROUP

##### *Smithistruma* (*Smithistruma*) *hyphata* new species

*Holotype worker:* TL 2.04, HL 0.56, WL 0.58, CI 63, MI 15. Outline of head from dorsal view and shape of clypeus much as in *S. dietrichi* of North America. Posterior occipital excision moderate; occipital lobes only weakly laterally expanded; preocular laminae subparallel, weakly convex, not forming a definitely continuous outline with the anterior converging borders of the occipital lobes, but approximately continuous with the sides of the clypeus and on to the apices of the closed mandibles. Center of verticociput with a shallow but fairly distinct median impressed area. Eyes very small, each with only about 4 to 6 pigmented facets, situated at the posterior third of the head length against the dorsal side of the cariniform ventral border of the antennal scrobe. Mandibles small and only moderately broad, viewed in place and closed like those of *S. dietrichi*. A third specimen (paratype) belatedly received from Dr. Weber permits a better characterization of the dentition than was previously possible.

Basal lamellae translucent, acutely triangular, with an acute internal spine reaching to apex; long diastema between the triangular portion of the basal lamella and the first tooth of the apical series, but this diastema almost completely filled in by a broad, straight-edged distal extension of the basal lamella; this extension almost as broad as the first three teeth of the apical series are long. The apical series follows the extension directly, and is distinctive in the proportionate lengths of the teeth. Nos. 1 to 3 subequal, rather stubby, but with acute apices; no. 4 much shorter than the first three; no. 5 very long and slender, much the longest tooth of the series and subequal in length to the basal lamella. Beyond this long tooth are several shorter, slender teeth becoming gradually shorter toward the apex; the number not exactly determinate, but estimated to be about 7 counting the apical tooth. All of the teeth of the apical series appear to have more or less acute apices.

Antennal scapes in repose reaching to about the posterior quarter of the head length, about 0.42 mm. long, nearly straight, slender at base and feebly fusiform, with the greatest thickness slightly distad of the midlength. Antennal funiculus about 0.64 mm. long; apical segment nearly or quite as long as I-IV taken together; II and III about equal and nearly as broad as long, but together not as long as I; IV about as long as I and much thicker.

Alitrunk distinctive, rather ruggedly modelled; promesonotum somewhat depressed, in profile appearing weakly and irregularly convex. Seen from above, the anterior margin distinct (but short and concave) only across the base of the rather strong, depressed neck. Oblique pre-humeral margins feebly concave and terminated by strong, bluntly tuberculate humeral angles; posterior to which the dorsolateral promesonotal borders are weakly convex and converging posteriorly to the mesonotal tubercles, faintly marginate. Promesonotal sulcus just barely suggested by a feebly darkened area. Weak median longitudinal carinula extending from pronotum onto neck and mesonotum. Posterior portion of mesonotum narrowed and impressed, the impression moderate, but in profile appearing abrupt

due to the sudden posterior decline of the two prominent, compressed dorsolateral mesonotal tubercles. Mesonotal impression terminated posteriorly by the weak metanotal groove; the latter not affecting the profile because the entire impressed region is bordered on each side by a weak, slightly irregular, but continuous cariniform border. Just anterior to the metanotal groove, the posterior mesonotal border is transversely indistinctly carinate; where the transverse border meets those of the sides of the dorsum on each side, there is raised a small piligerous tubercle. Propodeal dorsum anteriorly rising slightly but abruptly from the metanotal groove, its surface weakly convex anteriorly, but sloping off rather steeply to the declivity behind; dorsolateral margins distinct and continued posteriorly as the propodeal teeth. Teeth long and acute, about as long as the distance between the centers of their bases, compressed and lamelliform, their dorsal edges curving slightly dorsad toward the apices, divergent. Infradental lamellae reticulate, broadest at the bases of the teeth and gradually narrowing below, not widened at their ventral extremities.

Petiole pedunculate, with a moderately high, rounded node; nodal summit set off by a feeble carinula running all the way around near the top; anterior face on each side with a low lamelliform carinula running up from the peduncular dorsum and forming a tiny point or corner on its side of the anterior summit where it meets the encircling carinula. Between the two points so formed, the portion of the encircling carinula is stronger, dividing the convex disc of the summit from the sloping anterior nodal face. Seen from above, the disc of the summit is about as broad posteriorly as it is long, the sides arcuate and converging anteriorly, posterior border arcuate, anterior border or carinula transverse and very short. Ventral spongiform border about as deep as the peduncle itself; posterior of node on each side with a thin, leaf-like flap of vesicular spongiform tissue, the two flaps connected across the posterior surface of the node by a very narrow, thin lamelliform collar or isthmus. Postpetiole in dorsal view with dorsal disc subcircular, a little broader than long and about  $1\frac{1}{3}$  times as broad as the petiolar node, strongly convex, punctulate, opaque, with about 4 distinct, complete, transversely oriented costulae or rugulae. Spongiform appendages luxuriant; posterodorsal isthmus broad, but narrowed in the middle.

Gaster as in other *Smithistruma*, with lamelliform-spongiform pad on anteroventral face; basal costulae coarse and separated, about 15 in number, extending about  $\frac{1}{4}$  or slightly more the length of the basal tergite; remainder of gaster smooth and shining. Clypeus rather coarsely granulate and opaque; punctulation of head, alitrunk and nodes relatively coarse; occipital region and dorsum of promesonotum with very feebly superimposed rugulation; sides of posterior half of alitrunk smooth and shining. In addition to the larger lateral mesonotal tubercles already mentioned, there is a pair of small tubercles on the anterior mesonotal dorsum near the sides, each one extended anteriorly and posteriorly for a short distance as a feeble longitudinal carinula.

Pilosity consisting practically entirely of long to extremely long flagellate or subflagellate hairs, not particularly numerous, but so long and often intertangled as to suggest a sparse growth of fungal hyphae (given recognition by the name *hyphata*). Hairs on clypeus mostly very feebly thickened or at least obtuse apically, 12 to 14 very long ones directed outward, mostly laterally, but with the tips looping entirely back or nearly entirely back to the clypeal surface by way of broad dorsal curves. Anterior extremity of clypeus with a curious close-set group of 4 small hairs, directed anteriorly, the extreme tips curved ventrally. The small carinal lobes over the antennal insertions each with a long, straight tapered hair directed posteriorly and somewhat laterally. Upper dorsum of head with sparse long and very long filiform hairs, recumbent and mostly directed posteriorly; lateral border of each occipital lobe with two very long, fine, outstanding, straggling flagellate hairs. Dorsum of alitrunk with a sparse growth of fine subappressed shorter hairs and several bilaterally paired, very long, crooked or recurved flagellate hairs, the latter arising from the four pairs of tubercles already mentioned on the alitrunk. The pair of hairs arising from the posterior mesonotal tubercles are shorter than the other three pairs. Nodes and gaster with long and medium-long, weak flagellate hairs, sparsely arranged, and mostly arching back to the integumental surface. Antennal scapes with a few slender appressed hairs; legs with slender appressed or reclinate hairs.

Color even medium ferrugineous; antennal funiculi and parts of legs a bit lighter and more yellowish.

Holotype [Weber Coll.] collected with two paratypes in the foothills north of Tunapuna, Trinidad, B. W. I. (N. A. Weber; catalog no. 180). The paratypes are closely

similar to the holotype, and one, when measured, did not differ in dimensions by more than the expected error. [MCZ]

This species is entirely different from all the other known South American *Smithistruma*. The habitus, which recalls that of the *ornata* group of the Nearctic Region, is perhaps supported by the mandibular dentition in placing this species nearer to *dietrichi* than to any other known form. *Hyphata* is distinct enough on several counts to warrant placement in a separate group, but until the Neotropical fauna is much better known there is no harm in grouping it with the species to which it seems most closely related.

### Subgenus *Platystruma* new subgenus

*Strumigenys* (*Cephaloxys*) Fred. Smith, *sensu* Weber, 1934, Revista de Ent. 4:47, part. *Smithistruma* (*Smithistruma*) Brown, 1948, Trans. Amer. Ent. Soc. 74:105, part.

**Worker:** Head extremely depressed, the index of cephalic depression (ICD) not more than 31. Mandible with a broad translucent basal lamella; number of teeth in apical series reduced, all acute. Alitrunk depressed. Otherwise as in *Smithistruma* (*Smithistruma*).

**Subgenotype:** *Strumigenys* (*Cephaloxys*) *depressiceps* Weber.

#### SMITHISTRUMA (PLATYSTRUMA) DEPRESSICEPS (Weber)

Pl. II, fig. 18

*Strumigenys* (*Cephaloxys*) *depressiceps* Weber, 1934, Revista de Ent. 4:47-50, figs. 6, 14c, worker, male.

**Worker:** Weber described and figured this ant rather thoroughly in the original reference. Two cotypes were measured and found not to differ significantly from one another except in exposed length of mandibles: TL 2.70-2.72, HL 0.80, WL 0.77, CI 65, MI 12-13. Greatest depth of head at the weak occipital convexity, about 0.24 mm.; ICD 30 in both specimens.

Clypeus about half as long as the width across the occipital lobes and just about exactly as wide as long. Length of scape 0.28 mm. Head dorsally with a broad, shallow median depression of the vertex; occiput weakly convex. Labral lobes long, depressed, rod-like and subparallel, reaching at least  $\frac{3}{4}$  the distance to the mandibular apices and themselves truncate or strongly blunted apically. Mandibles as in the figure, not with rounded basal lamina as Weber states in his description.

Numerous short, fine, erect truncate hairs on the dorsal body surfaces except clypeus, which has extremely fine, short, obliquely erect hairs on the disc, these invisible in most angles of view even at high magnifications in strong light. Hairs on free clypeal border numerous, small and finely spatulate, curved medially, those on the sides of the clypeus longer than those on the center of the anterior portion of the border and larger than as shown in Weber's figure.

**Male:** Described and the volsella figured satisfactorily by Weber in the original reference.

**Type locality:** Kartabo, British Guiana (W. M. Wheeler). The type series was taken from a cavity in a rotten log. Types in MCZ.

#### KEY TO THE WORKERS OF SMITHISTRUMA S. STR.\*

1. Sides of at least the posterior half of the alitrunk largely smooth and shining ..... 2
- Sides of alitrunk completely or very nearly completely and densely punctulate ..... 7
2. Clypeus with very long (approximately as long as clypeus itself) subfiliform hairs directed away from the center, but strongly recurved dorsomesad, the apices returning toward the center of the disc (other body hairs fine and filiform; habitus that of *ornata* group; Trinidad) ..... *hyphata* n. sp.
- Clypeus with much shorter ( $\frac{1}{3}$  or less the length of clypeus), spatulate or spoon-shaped hairs, appressed or reclinate on the clypeal disc and forming an even fringe on its free border ..... 3
3. Mandibles long, MI over 25, very nearly or quite as long as the clypeus. (CI 77

\* This key applies to species of the Neotropical Region.

- or more; mandibular dentition as in fig. 17; Vera Cruz to Bolivia, Lesser Antilles  
*alberti* (Forel)  
 Mandibles shorter, MI less than 25, distinctly shorter than clypeus; (CI less than 77; mandibular dentition diverse, never as in fig. 17) ..... 4
4. Alitrunk completely or nearly completely smooth and shining, dorsally without distinctly punctulate areas; MI 16-17; HL over 0.55 (S. Brazil) ..... *sublucida* n. sp.  
 At least the mesonotum and dorsum of propodeum with punctulation distinct and dense; MI 19 or over; HL usually less than 0.55 ..... 5
5. Propodeal teeth long, straight and slender, the infradental lamellae reduced to mere fine carinae (entire pronotum punctulate; basal mandibular lamella narrowly rounded apically; Argentina) ..... *conspersa* (Emery)  
 Propodeal teeth involved basally with the more or less raised and distinct infradental lamellae (pronotum usually with sculpture either partly effaced or partly substriated) ..... 6
6. Free posterodorsal face of petiolar node approximately as long as broad and as long as the free postpetiolar disc (preocular laminae nearly or quite parallel; anteromedian section of pronotum nearly or quite smooth, except for median carinula, shining; dentition as in fig. 21; S. Brazil) ..... *friderici-mulleri* (Forel)  
 Free posterodorsal face of petiolar node considerably broader than long and about 2/3 the length of the free postpetiolar disc (preocular laminae decidedly converging anteriorly; pronotal punctulation overlain by variably distinct longitudinal striation; dentition as in fig. 15; Central America, Greater Antilles) ..... *nigrescens* (Wheeler)  
 7. Ventral appendages of petiole present and distinctly spongiform, fairly well developed; infradental lamellae broad, convex below (dentition as in fig. 23; tropical Mexico to Central America) ..... *epinotalis* (Weber)  
 Ventral petiolar appendages entirely obsolete or present as very fine cariniform vestiges; infradental lamellae vestigial or narrow and concave ..... 8
8. Propodeal teeth slender and very acutely tapered, their infradental lamellae obsolete and represented only by fine carinae; basal tergite of gaster distinctly, very finely and densely striolate-punctulate, opaque (mandibular dentition as in fig. 20; West Indies, S. U. S. to Colombia) ..... *margaritae* (Forel)  
 Propodeal teeth broader at their bases, involved with the low but not cariniform infradental lamellae; basal tergite of gaster with anterior striation or costulation, but posteriorly smooth or indistinctly shagreened, strongly to weakly shining ..... 9
9. Pilosity of head and dorsum of alitrunk of uniformly large, curved spoon-shaped hairs; no erect, bilaterally paired specialized hairs; sculpture of postpetiolar disc very feeble, partly effaced, the surface more or less shining (mandibular dentition as in fig. 22, S. Brazil) ..... *alegrensis* n. sp.  
 Pilosity of head different, usually with a few differentiated erect hairs on occiput and alitrunk; postpetiole distinctly and densely punctulate-granulose, opaque ..... 10
10. Size larger: TL over 2.15, HL over 0.58, CI 70-73 (color dark; dentition as in fig. 24; Venezuela) ..... *orchibia* n. sp.  
 Size smaller: TL under 2.15, HL under 0.58, CI usually over 73 (color light or dark, varying with species) ..... 11
11. Species of which specimens were examined for this revision: TL 1.80-2.10, HL 0.51-0.55, CI 75-79, MI 15-18; free posterodorsal face of petiolar node not or only extremely slightly broader than long ..... 12  
 Species of which specimens were not available for this revision, characterized according to the original descriptions: TL same as above or distinctly smaller; free posterodorsal face of petiolar node distinctly broader than long ..... 13
12. Ground pilosity of verticocapit appressed or subappressed, the hairs numerous, small, spatulate, mostly directed anteriorly and not obliquely medially; color ferrugineous yellow (Costa Rica) ..... *studiosi* (Weber)  
 Ground pilosity of verticocapit consisting of small inverted spoon-shaped hairs, mostly directed sharply obliquely toward the midline; color deep reddish-brown, the head and gaster darkest; appendages yellowish (Colombia) ..... *castanea* n. sp.
13. Size small, TL probably under 1.90, HL probably 0.51 or less (see discussion in text. Amazon Basin) ..... *schulzi* (Emery)  
 Size probably agreeing better with couplet 11, lug A (see discussion in text. Para-

guay) ..... *emiliae* (Forel)  
 The single known species of *Platysturma*, *P. depressiceps*, is easily distinguished from the species in the key above by virtue of its broad, extremely depressed head, this more strongly flattened than in any other species of ant known to me.

#### INDOMALAYAN, PAPUAN AND OCEANIAN SPECIES OF SMITHISTRUMA

##### CAPITATA GROUP

Tropical Asian, Papuan and Oceanian species resembling the Neotropical species *alberti* and *nigrescens* in many details. Nine species are here recognized, of which several are doubtfully distinct. One of these, *mumfordi* Wheeler, is insufficiently described, and may well belong to some genus other than *Smithistruma*. The other eight species can be divided into two subgroups on the basis of size.

1. Small species: *karawajewi* Brown, *dubia* new species.
2. Large species.
  - a. Papuan-Philippine species; propodeal dorsum weakly convex: *capitata* Fred. Smith, *pedunculata* new species.
  - b. Indomalayan species; propodeal dorsum flat: *dohertyi* Emery, *lamellignatha* new species, *inezae* Forel and *taipingensis* Forel.

The species of subgroup 1 are quite distinct from the others and from one another. The species in subgroup 2 are a different story, and it is only after the greatest difficulty that I have been able to state their probable placement in this group. The oldest species, *capitata*, was first described from the female; Emery later gave a hasty description and figure of the worker, but I have not been able to see any specimen of this caste. I have described a second species (*pedunculata*) in section 2a, although I realize that the workers of the two species are at best only very slightly different. Differences in the *pedunculata* female, which was directly compared with the type of *capitata*, seem more significant, and I have therefore decided that at least one form of this section should bear a certainly applicable name until better collections are available for study.

In section 2b, much the same situation exists. I have described *lamellignatha* from Borneo in order that the worker, female and male of at least one species of this subgroup should be adequately described and unequivocally associated. Actual specimens of the other three 2b species had not originally been seen by me, and since the original descriptions of these forms were each inadequate or questionable in some important respect, I was hard put even to be sure that I had placed them to the correct genus.

Only just before writing this, I have managed to gain information concerning *taipingensis* which shows beyond a doubt that it is a 2b form, though I still cannot say whether it should be synonymized with one of the other forms. Still more recently, I have had the rare good fortune of being permitted to see the *dohertyi* holotype. *Dohertyi* differs only very slightly from *lamellignatha*, showing that the eventual treatment of all 2b species may be as slight, non-taxonomic variants of one species ranging from Burma to Java and Borneo and bearing the prior name *dohertyi*. Such treatment is presently blocked by our lack of complete knowledge of the two forms *inezae* and *taipingensis*, which are described as having smooth and shining postpetioles. The



postpetiole in both *lamellignatha* and *dohertyi* is longitudinally striate (as also in *pedunculata* and *capitata*), and it would not be at all surprising to find that Forel had made one of his common mistakes in describing sculptural detail under the names *inezae* and *taipingensis*. His measurements are probably inaccurate.

Since these two species were each described from a single specimen, the types are not available for study, and that of *inezae* may be permanently lost. The status of these forms will have to be worked out on the basis of topotypic and other Indomalayan collections in this group. I have given below as much information about each of the species as I could obtain, and if this treatment will aid some future worker to synonymize Forel's species and *lamellignatha* under *dohertyi*, it will have served its primary purpose well enough.

I give here a general description applying to all the species of subgroup 2 that I have seen to date:

*Worker*: Large species; TL ranging from 2.35 to 2.85 mm. Head broadly cuneiform, with laterally expanded occipital lobes and strong posterior occipital excision, CI 76-84. Preocular laminae converging anteriorly and continuous with sides of clypeus and closed mandibles to form a nearly straight-sided V when head is viewed full face. Clypeus slightly but distinctly broader than long, with a broadly rounded free border; anterior portion of disc feebly depressed. Antennal scrobes deep and broad; eyes moderate in size, only weakly convex. Mandibles large, robust, weakly depressed and their apices only weakly deflected downward; nearly as long as to slightly longer than the clypeus (considering only the normally exposed mandibular length) and 1/4 to 1/3 as long as the head proper. Dentition probably similar in all species; identical in those seen for this revision, as in fig. 14. Antennal scapes gently bent at or near the basal third, varying somewhat in length and shape with the species. Funiculus of normal *Smithistruma* pattern; apical segment very slightly longer than segments I-IV taken together.

Promesonotum forming one strong convexity, with slight or no trace of humeral angles. Posterior mesonotum depressed; propodeum narrow, its dorsum low and plane or gently convex. Propodeal teeth moderate in size, acute; infradental lamellae reduced to low carinae. Petiole pedunculate, with a distinct node, varying somewhat in form with the species. Postpetiole broader than long, strongly convex; in the species seen for this revision, longitudinally striate. Spongiform appendages present and fairly well developed on and under both nodes. Gaster with a transverse anterodorsal margin of spongiform tissue; basal gastric costulae short but distinct. Gaster otherwise smooth and shining, as are also (usually) part at least of the mesopleura. Head, alitrunk, and appendages densely punctulate and opaque, except as noted.

Ground pilosity consisting of moderately abundant, rather inconspicuous subappressed spatulate hairs on head and promesonotum. Hairs of clypeal disc also sparse, subappressed, small and sublinear-spatulate, those on the free border a little larger, 7-8 on each side of the midline, rather uniform in size and not conspicuous, narrowly linear-spatulate and curved weakly anteriorly and medially. Hairs on anterior border of scape usually outstanding, slender, with spatulate or subclavate tips. Hairs 1 and 2 (before bend) rather short,

bent toward scape apex; 3 the largest hair, both it and 4 curved toward the base of the scape; 5 varying in direction with the species; beyond this, there are two or three apically curved, small slender hairs near the scape apex. Erect hairs of the "typical" pattern; a row of four stiffly erect, narrowly spatulate or subclavate hairs on the posterior occiput; in front of this, another row of the same, the two lateral hairs of this anterior row situated on the lateral borders of the occipital lobes and directed laterally. Each humerus bears a long, outstanding stiff or flagellate hair; two pairs on the mesonotum; two pairs on the petiolar and three pairs on the postpetiolar nodes, inclined posteriorly; 4-6 irregular transverse rows of about 4 hairs each on the gastric dorsum. With the exception of the flagellate humeral hairs of the *dohertyi* complex (section 2a), all the longer erect or suberect hairs of the body are weakly spatulate or subclavate at their apices. Color light to dark ferrugineous.

*Female:* Size larger overall than in worker, TL 3.1-3.6 mm. Differing from the worker chiefly in the usual sexual characters, although the head in at least one species (*lamellignatha*) is not relatively significantly wider than in the worker; the mandibles of all species known in this sex appear little if any shorter in relation to the head proper than in the worker caste. The form of the petiole is different from that of the workers, and differs in what seems to be a significant way among the species for which this sex is known.

*Male:* This sex certainly known and associated with workers only in *S. lamellignatha*, which see.

The two smaller species, *dubia* and *karawajewi*, are somewhat similar in general form to the members of subgroup 2, but in addition to the smaller size, they differ in having relatively shorter mandibles, those of *dubia* having quite distinctly different dentition. *Karawajewi* is a very small form according to the original description, and has a narrower clypeus and different pilosity.

The species of *Smithistruma* presently known from the region under consideration are considerably more like one another than are the forms of the two other widespread genera occurring there; *Weberstruma* and especially *Strumigenys* are represented in the area by very distinctly different species, showing that they have probably been differentiating there for a longer time. *Smithistruma* is not yet known from eastern New Guinea or Australia, while many species of *Strumigenys* are common throughout these regions. Although one or two species of *Smithistruma* have managed to get out into distant Pacific archipelagoes, they have probably done this only as tramps through the agency of human commerce. It therefore seems fairly certain that *Smithistruma* arrived in southeastern Asia much later than did *Strumigenys*; the East Indian fauna of *Smithistruma* has only begun to differentiate and expand there, and the relationships to the Mediterranean *baudueri* group and the Neotropical *alberti* group suggested by morphological similarities of certain species are quite possibly as close as they seem at a superficial glance.

Scarcely anything is known of the biology of the *capitata* group; most of the few records given indicate that the colonies are commonly taken in rotten logs, under bark, etc. The large species seem to fill the same ecological role as does *alberti* in the New World, while it may not be stretching the thin

evidence to say that *dubia* may parallel *nigrescens* in its ability to act as an insular tramp.

The large species of group 2 seem to be recorded entirely or nearly entirely from mountainous areas, and it may be that the few species represent populations entirely isolated from one another in this respect.

SMITHISTRUMA (SMITHISTRUMA) CAPITATA (Fred. Smith)

*Cephaloxys capitata* Fred. Smith, 1864, Journ. Proc. Linn. Soc. Lond. Zool. 8:77, Pl. 4, figs. 5, 5a, 5b, female. *Strumigenys capitata* Mayr, 1866, Sitzb. Akad. Wiss. Wien 53:517. Emery, 1887, Ann. Mus. Stor. Nat., Genova 25:44-45, Pl. 2, figs. 20, 21, worker, female, ?male. 1897, Term. Füzetek 20:576, worker, in key. *Strumigenys (Cephaloxys) capitata* Mann, 1921, Bull. Mus. Comp. Zool., Harvard 64:462. Emery, 1922, Gen. Ins. Fasc. 174:324. Donisthorpe, 1932, Ann. Mag. Nat. Hist. (s. 10) X:474. 1948, Psyche 55:80-81, female. *Smithistruma (Smithistruma) capitata* Brown, 1948, Trans. Amer. Ent. Soc. 74:105.

*Holotype female*, redescribed: TL 3.32, HL 0.67, WL 0.94, CI 88, MI (only one mandible, so this is an estimate) 23. Corresponds very well to the worker description given for subgroup 2, the larger species of the *capitata* group, but differing in the normal features of full sexuality. Eyes very large, elliptical, convex, about 0.18 mm. long in greatest diameter. The single remaining mandible is bent slightly inward; in normal position, it would probably not be more than  $\frac{1}{4}$  the length of the head proper or much more than  $\frac{3}{4}$  the length of the clypeus. The head is shorter and broader, and the mandibles markedly smaller, than in the gynotype of *pedunculata* (see below). Dentition of mandible easily seen, agreeing in detail with that of *pedunculata* (see fig. 14). Exposed length of antennal scape about 0.35 mm.; gently angled (about  $35^\circ$ ), broadest just beyond bend, anterior border broadly rounded. Funiculus about 0.53 mm. in length, of which very slightly more than half is taken up by the apical segment; II + III a bit shorter than I or IV; II very slightly longer than broad; III slightly broader than long.

Alitrunk robust; with feeble median longitudinal carinula, almost imperceptible on the scutellum; the latter bluntly rounded behind in any view. Propodeal teeth thick, triangular, about as long as broad at their bases. Petiolar node seen from the side with a strongly rounded summit; peduncle thick, about half the length of the node; nodal declivity sloping from the peduncular dorsum at an angle of about  $40^\circ$ . Node seen from above 0.16 mm. long, 0.24 mm. broad; each side of anterior declivity with a feeble carinula running down onto peduncular dorsum. Posterior spongiform collar narrow, extending halfway up the sides of the node toward the anterior declivity as narrow, horizontal, sliver-like lobes; midventral strip moderately well developed. Postpetiole transversely elliptical, broadest posteriorly, disc strongly convex, with a distinct median posterior impression like that found in most *Smithistruma*. The disc is about 0.21 mm. long and about 0.34 mm. broad. The measurements of the petiole and postpetiole are subject to a maximum error of  $\pm .01$  mm. Contrary to previous descriptions of this specimen by Smith and Donisthorpe, the postpetiolar disc is densely and finely longitudinally striate its length, but still more or less shining; sides of node with striation more or less effaced and more strongly shining. Spongiform appendages of the postpetiole are moderately well developed, but appear to have been partly torn away; probably Smith or some other early worker thought these represented foreign material fouling the surface. Gaster rather large; first tergite taking up more than  $\frac{4}{5}$  the length; anteroventral pad and thin transverse antero-dorsal spongiform border present. Basal costulae about 20 in number, varying in length, but mostly distinct, the longest ones extending only about  $\frac{1}{8}$  to  $\frac{1}{7}$  the length of the basal tergite.

Head, alitrunk, petiole and appendages evenly and densely punctulate and opaque; mesepisterna smooth and shining. Pilosity largely rubbed off, but few remaining hairs show that the pilosity must have been much as in the worker and female of *pedunculata*.

Color deep ferrugineous; gaster slightly darker; ocellar triangle blackened; appendages lighter and more yellowish.

I owe the opportunity of seeing the type to the kindness of Professor Varley and Mr. Ernest Taylor of the Hope Department of Entomology at Oxford University Museum, in which institution the specimen now rests. Mr. Donisthorpe's redescription of 1948 is in error regarding several important features of this insect; since he published the redescr-

tion in order to facilitate this revision, I doubly regret having to take issue with him concerning these points.

*Worker:* Emery described and figured the head of the worker in 1887 (loc. cit.), and I am of the opinion that his determination is correct. His figure, when measured, shows a CI of about 86 and MI about 23, corresponding very closely to the same values for the female given above. This is significant in view of the fact that the workers and females of the other *capitata* group species I have seen show only slight differences in size and proportions of the head and mandibles. We may assume, I think, that the worker of *capitata* differs from that of *pedunculata* as does the female, i.e., the head is probably shorter and broader on the average, and the mandibles distinctly shorter. Emery mentions the longitudinally striate postpetiolar disc in his specimens. As much of the pilosity as is shown is like that of *pedunculata*, except that the hair on the anterior border of the scape corresponding to no. 5 in *pedunculata* is curved toward the scape base (this curved apicad in normal specimens of *pedunculata*). Mr. Donisthorpe (in litt.) has pointed out that the proportions of the funicular segments in Emery's figure do not correspond exactly to those of the type female. It seems to me, however, that this very slight difference may be put down as another of Emery's numerous draughting errors. Neither Emery nor Donisthorpe saw the broad basal lamella of the inner mandibular border; this is present in the type and in all of the other *capitata* group workers and females I have seen. Emery also mentions the depression of the "sutura meso-metanotale," which must therefore be distinct.

*Male:* The specimen described by Emery, stated to have been taken at the same locality as were the workers described in the same article, seems to me not to belong to *Smithistruma*. The notched structure of the ends of the mandibles and the shape of the eyes are so different from those of the surely-associated male of *lamellignatha* that I cannot believe two species with such similar workers would have such different males. Males of other species groups in this genus have proven very similar from species to species within one group. I believe that Emery's male belongs to some species of *Strumigenys*. The types of worker and male castes in Emery Coll.

*Type locality:* New Guinea (A. R. Wallace). Wallace apparently collected this insect somewhere on the western end of New Guinea. The type was the only specimen examined that could be referred to this species.

Emery's workers, female, and male were taken by Beccari at Ramoi, New Guinea. The records given below, published under the name "*Strumigenys capitata*," are considered as probable misidentifications based on some Indomalayan (section 2b) species:

Emery, 1901, Ann. Mus. Civ. Stor. Nat., Genova, XL, p. 691: Bua Bua, Engano I. (E. Modigliani). Santschi, 1928, Tijdschr. v. Ent., LXXI, p. 130: Boschreserve Bandar, Sumatra (J. B. Corporaal).

*Capitata* is apparently widespread in western New Guinea and neighboring islands. Collections of *Smithistruma* from areas such as Moluccas and Mindanao, between known ranges of *capitata* and *pedunculata*, should help to make clearer the relationships between these two very close forms.

#### *Smithistruma* (*Smithistruma*) *pedunculata* new species

Pl. I, fig. 14

*Holotype worker:* TL 2.49, HL 0.60, WL 0.65, CI 80, MI 27. Agrees well with the general characterization for the large members of the *capitata* group given above. The head is probably a little narrower than that of *capitata*, and the mandibles a little longer. The overall size is smaller than in *lamellignatha*, and the mandibles are relatively smaller, but the proportions of the head are about the same. Normal exposed length of antennal scape 0.32 mm. (paratypes: 0.31-0.33 mm.), bent near basal third at about a 35° angle, the anterior border weakly and obtusely angulate or subangulate. Incrassation rather strong, the greatest width of the scape coming a little beyond the bend, at about the second fifth of the scape length. Beyond the bend, the anterior scape border weakly convex, becoming feebly concave at the extreme apex. Alitrunk in profile with a very strongly convex promesonotum, concave posterior mesonotal depression, and gently convex propodeal dorsum. Propodeal teeth about half as long as the distance between the centers of their bases, acute and elevated.

Petiolar node low and broadly rounded in profile, slightly longer than its peduncle, with gently sloping anterior declivity. Seen from above, the node is as long or very

slightly longer than broad, subcircular, with convex sides, broadest posteriorly.

Median longitudinal carina of pronotum moderately distinct; shining area of mesopleura restricted to a narrow oblique band running along the anteroventral mesopleural border. Postpetiolar striation strong and distinct, noticeably more distinct than in *lamellignatha* or the *capitata* type. The postpetiolar surface is therefore duller and more opaque in most lights than in most other forms. Basal gastric costulae 14-17, extending  $1/5$  to  $1/4$  the length of the basal gastric tergite.

Erect hairs on dorsum of body long, stiff, but shorter and a little stouter than those of *lamellignatha*; posterior mesonotal pair ca. 0.10 mm. long; anterior mesonotal pair shorter than posterior pair; humeral hairs stiff, more or less flattened at tip and definitely not flagellate or subflagellate, as those of *lamellignatha* are. Of the hairs on the anterior scape border, no. 3 is not quite as long as the scape is wide at its widest point; hair no. 5 curved toward scape apex.

Color dull yellowish-ferrugineous.

Holotype selected from a colony-series taken at Camp 4-18-27, near Dumaguete, Negros Oriental, Philippine Islands (J. W. Chapman, cat. no. 1378) "from log in wet draw, April 1927." Placed in MCZ.

*Paratypes*: 44 workers taken from the type nest and from two other nests taken on different occasions in the vicinity of Dumaguete (J. W. Chapman, cat. nos. 1355, 1361). TL 2.43, HL 0.58-0.62, WL 0.65-0.72, CI 79-84, MI 25-29. Slight variation in length and form of propodeal teeth and in number and placement of erect hairs on gastric dorsum. Exposed mandibles averaging very slightly shorter than clypeus. One specimen with a small extra hair on the left anterior scape border between hairs no. 3 and 4, this small hair curved toward the scape base. Callows light yellowish-ferrugineous, older workers medium ferrugineous. Deposition in MCZ, Chapman Coll., USNM, ANS, Consani Coll., etc.

*Gynotype female*, dealate: TL 3.34, HL 0.69, WL 0.90, CI 85, MI 29. Differing from the worker in the usual ways. Scape 0.38 mm. long, shaped as in worker. Petiolar node low and rounded, the peduncle rather slender and about equalling it in length. Seen from above, the node only very slightly broader than long, with a very feeble impressed or flattened area in the middle of the posterodorsal face. Postpetiolar node about 0.35 mm. wide,  $3/4$  again as broad as long and nearly  $3/4$  again as broad as the petiolar node. Striation very fine, crowded but distinct, the surface weakly shining. Basal gastric costulae much coarser and larger than in the worker, extending about  $1/3$  the length of the first gastric tergite. Katepisternum and anterior lobe of anepisternum (of mesothorax) smooth and shining. Median longitudinal carinula weakly indicated on scutum. Exposed length of closed mandibles about equal to the clypeus in length. Gynotype with the same data as for holotype, with which it is deposited. Male unknown.

*Pedunculata* quite definitely belongs to the eastern section of the complex (subgroup 2) of larger *capitata* group species. This section is distinguished from the western or Indomalayan section by the slightly smaller size, relatively smaller mandibles, shorter and broader scapes, convex propodeal dorsum and by the thickened humeral hairs. Within the eastern section, *pedunculata* is best differentiated in the female caste (because the *capitata* worker remains incompletely characterized) by means of the long-pedunculate, narrow petiole. The mandibles of both female and worker *pedunculata* appear to be longer, at least in the average, than those of *capitata*. A minor feature, but one which is used for the workers in the key, is the difference in curvature of the fifth hair on the anterior scape border. This rather feeble character depends on the accuracy of Emery's drawing of the worker *capitata*. Redescription of the *capitata* worker on a quantitative basis is urgently needed.

#### *Smithistruma* (*Smithistruma*) *lamellignatha* new species

Pl. III, fig. 33

*Holotype worker*: TL 2.80, HL 0.65, WL 0.77, CI 80, MI 28. See general description of large members of *capitata* group. Body large; mandibles approximately as long as the clypeus or very slightly longer. Antennal scapes long and slender, bent at an angle approaching  $35^\circ$  near the basal third; exposed length about 0.40 mm. Incrassation of scape very slight; anterior border distad of bend nearly straight, the anterior and posterior borders nearly or quite parallel from near the bend to near the apex, where the scape narrows slightly and gradually and is feebly curved anteriorly. Funiculus 0.59

mm. long, apical segment slightly longer than I-IV taken together.

Propodeal dorsum in profile very nearly straight, with only the merest feeble suggestion of convexity, continuous with the posterior mesonotum. Propodeal teeth straight, a little more slender and acute than in *pedunculata*, about  $2/3$  as long as the distance between the centers of their bases, gently elevated, scarcely divergent. Infradental lamellae reduced to fine carinulae. Petiolar node rather low and rounded, but with moderately steep anterior face; seen from above, node very slightly longer than broad and slightly but distinctly longer than its peduncle. Spongiform appendages slightly less well developed than in *pedunculata*. Postpetiolar node about 0.24 mm. wide, about  $1\frac{1}{3}$  times as broad as long and about  $1\frac{1}{2}$  times as broad as the petiolar node, strongly convex above, the longitudinal striation less distinct than in *dohertyi* or even than in *pedunculata*, almost completely effaced on the sides, but still quite evident even at moderate magnifications. Basal gastric costulae numbering about 15, very short, separated, occupying about  $1/7$  to  $1/6$  the length of the basal gastric tergite. Mesopleurae and the gastric dorsum except for basal costulae smooth and shining.

All body hairs longer, with tips slightly more broadly spatulate than in *pedunculata*, the posterior mesonotal pair 0.12-0.13 mm. long; humeral and lateral occipital paired hairs long and crookedly flagelliform. Of hairs bordering scape anteriorly, nos. 3, 4, and 5 bent weakly basad, the rest curved toward apex.

Color clear yellowish-ferrugineous.

Holotype taken on Mt. Tibang, North Borneo, 1300 meters, in a rotten log (E. Mjöberg) with other workers and winged sexual forms described below. Holotype in MCZ.

*Paratypes*: [MCZ, USNM, etc.] Of a small group of workers taken with the holotype, several were headless, and some reached me too late for the proper measurements to be included here. Four individuals (workers) were fully measured, and the rest did not seem to vary very much from these. TL 2.72-2.83, HL 0.64-0.65, WL 0.72-0.78, CI 78-83, MI 28. Variation in length and degree of divergence of propodeal teeth present but very slight. Most individuals were a little darker than the holotype, medium ferrugineous with slightly darker gasters. Flagellate hairs of humeri often with the attenuated tips looped back and adhering "buggy-whip" fashion to the thicker part of the shaft, thus sometimes appearing falsely spatulate. Median longitudinal carinula of pronotum often indistinct, at best not very strongly developed.

*Gynotype female*, alate: TL 3.56, HL 0.75, WL 0.98, CI 78, MI 28. Length of forewing 3.35 mm. Exposed length of mandibles equal to length of clypeus. Petiolar node low and rounded, as long as its peduncle; carinula on each side of anterior nodal face distinct; seen from above, the node subtrapezoidal, about 0.21 mm. wide and about 1.25 times as broad as long. Postpetiolar node about 0.32 mm. broad and about 1.6 times as broad as long, more distinctly and coarsely striate than in the worker. Basal gastric costulae extending about  $1/4$  the length of the first gastric tergite, not so distinct as in the female of *pedunculata*, but a little more distinct than in the *capitata* type. Mesothoracic katepisternum and lower half of anepisternum smooth and shining. Color medium ferrugineous: head yellowish-ferrugineous, with ocellar triangle infuscated. Forewing with  $R + Sc$ , stigma,  $2r$ ,  $M + CuA$ ,  $Mf_1$  and  $Rsf_1$  distinct, well defined and pigmented;  $Rs + M$ ,  $r-m$ ,  $Rsf_4$  and  $Mf_4$  present but poorly defined and scarcely pigmented.

Gynotype taken from the type nest; deposited in MCZ.

Three *paratype females* also taken from the type colony: TL 3.41-3.57, HL 0.73-0.75, CI 79-81, MI 28. Two specimens are wingless. Color medium to darkish ferrugineous, head not lighter than rest of body; interocellar space blackened. Deposited MCZ, USNM, etc.

*Allotype male*: [MCZ]. Taken with the holotype. TL 2.51, HL 0.47, WL 0.68, CI 77 (eyes not included in measurements of head width). Greatest diameter of eye about 0.18 mm., slightly greater than the full length of a mandible (0.14 mm.). Eyes nearly perfectly half-globose and strongly protruding. Mandibles reduced, but the simple, acute apices opposable; apical and basal borders separated by an obtuse angle. Petiole with a very low node, its summit seen in profile forming a long arc; seen from above, the node is  $1\frac{1}{3}$  times longer than broad and nearly twice as long as its peduncle. Postpetiole seen from above subcircular, about as broad as long, the posterior border transverse. Both nodes with extremely fine cariniform traces of spongiform tissues, virtually obsolete, but apparently distributed as in the female castes. Both nodes finely granulose



on the sides, smooth and shining dorsally. Propodeal teeth represented by very low obtuse angles. Base of gaster with extremely short vestigial costulae, gaster otherwise smooth and shining. Head and alitrunk granulose-punctulate and opaque, except for the largely smooth and shining meso- and metapleurae. Head proper, pro- and mesonotum brownish-black; mesopleurae and parts of the body behind these castaneous; mandibles and genitalia lighter and more yellowish. Wings as in female, but shorter (2.6 mm.) and a bit darker in color; apical abscissa of M completely lacking. Another male from this collection (type nest) agrees well with the allotype except that the color is a little darker and the propodeal teeth a little better developed and more dentiform.

Distinguished in worker and female castes from *capitata* and *pedunculata* by size and proportions, especially of head, mandibles and antennal scapes, also by the scarcely convex propodeal dorsum; from *dohertyi* by the slightly longer, lower petiolar node, and presumably from *inezae* and *taipingensis* in having slightly (relatively) shorter mandibles and striate postpetiole.

#### SMITHISTRUMA (SMITHISTRUMA) DOHERTYI (Emery)

*Strumigenys dohertyi* Emery, 1897, Term. Füzetek 20:576, worker, in key and footnote. *Strumigenys* (*Cephaloxys*) *dohertyi* Emery, 1922, Gen. Ins. Fasc. 174:325. *Smithistruma* (*Smithistruma*) *dohertyi* Brown, 1948, Trans. Amer. Ent. Soc. 74:105.

*Worker*: Emery's description consists of a mere two lines in a key, totally inadequate for purposes of placing this ant. He states that the length is "2 1/3 mm." Fortunately, I have been able to see the type through the kindness of Dr. Delfa Guiglia of the Museo Civico di Storia Naturale at Genoa. The type has been returned to Genoa. TL 2.83, HL 0.67, WL 0.73, CI 76, MI 28. Antennal scape, exposed length, 0.36 mm., funiculus 0.54 mm.

The specimen is nearly identical to *lamellignatha* new species, described above, except that in *dohertyi* the petiolar node as seen from above (free portion) is distinctly but slightly broader than long. The long erect hairs of the gastric dorsum are a little longer and more slender, being scarcely enlarged apically, than in *lamellignatha*. Postpetiole distinctly and completely striate its length, subopaque; propodeal teeth stout and rather strongly diverging. Humeral hairs flagelliform as in *lamellignatha*. Mesopleurae covered with glue, so that their sculpture could not be determined. The holotype is labelled "Alta Birmania (Doherty)" and is in fairly good condition.

When more collections from the Indomalayan area are in, it may well be possible to show that *dohertyi*, *lamellignatha*, *inezae* and *taipingensis* are slight geographical or non-taxonomic variants of one species. In view of the widely different localities and the slight but seemingly constant differences shown by the few specimens I have seen, I think that it is best to regard these four forms as separate species for the time being.

#### SMITHISTRUMA (SMITHISTRUMA) INEAE (Forel)

*Strumigenys inezae* Forel, 1905, Mitt. Naturh. Mus., Hamburg 22:12-13, worker. *Strumigenys* (*Cephaloxys*) *inezae* Emery, 1922, Gen. Ins. Fasc. 174:325. *Smithistruma* (*Smithistruma*) *inezae* Brown, 1948, Trans. Amer. Ent. Soc. 74:105.

*Worker*: This species was described by Forel as "L. 2.4 mm., nahe *S. capitata* Sm." Circumstantial evidence indicates that the length in terms of TL would be well over 2.5 mm. Forel states that the head is much narrower behind than in *capitata*; the mandibles are described as longer than those of *capitata*, the propodeal dorsum as "flach," the petiolar node longer than broad, and the dorsum of the postpetiolar node "glatt." These features are enough to separate *inezae* from the other members of the *capitata* group, provided, of course, that Forel's description was accurate. I personally am a little skeptical of the statement concerning the "glatt" postpetiolar disc; I think it a least possible that this segment is striate as in other species, but with the sculpture slightly effaced in the middle. If such proves to be the case, we will need to reexamine the relationships of *inezae* and *lamellignatha*. The type was taken by K. Kraepelin at Tjibodas, Java, deposition in NM Hamburg. The type may have been destroyed during the war; it is definitely not in the Forel Coll. No second collection has been reported, and there are no specimens among those sent me by the Buitenzorg Museum.

Forel and Wheeler placed names on variants considered infraspecific to *inezae*, but I have removed these forms as separate species because of the evidence suggesting that they are not subspecies. The form named as *Strumigenys* (*Cephaloxys*) *inezae* var. *rudinodis*



by Stärcke has no close relationship whatsoever to *inezae*; it is an independent species belonging to the genus *Weberistruma*.

SMITHISTRUMA (SMITHISTRUMA) TAIPINGENSIS (Forel)

*Strumigenys inezae* var. *taipingensis* Forel, 1913, Zool. Jahrb. Syst. 36:83, worker. *Strumigenys* (*Cephaloxys*) *inezae* var. *taipingensis* Emery, 1922, Gen. Ins. Fasc. 174:325.

**Worker:** Information received recently from Dr. H. Bischoff, including a camera lucida sketch of the head and measurements of head and mandibles made from the type (ZMUB), allows me to say that this form quite definitely belongs to the *capitata* group. According to Dr. Bischoff's measurements and figures, the CI of the type would be 80 or slightly more, and the MI a bit over 30; the absolute head length is given as about 0.6 mm. With this head length, one would expect the total body length to be closer to 2.5 mm. than to the bare 2 mm. quoted by Forel. The exposed length of the mandibles seems to be very slightly longer than the clypeus.

The original description, which consists of a very brief comparison against *inezae*, does not state whether the petiolar node is longer than broad and the postpetiolar dorsum smooth and shining, but it implies that the form is similar to *inezae* in these respects. When more information is available concerning this species, we may be able to synonymize it with *dobertyi*. At present, the distinguishing characters seem to be the long mandibles and the size, which is stated by Forel to be definitely smaller than that of *inezae*. Of course, the measurements of *inezae* do not seem to be trustworthy, so we shall have to wait for further examination of the type or for further Indo-Malayan collections to find out what relationship *taipingensis* has to the other members of the *capitata* group. *Type locality:* Maxwell's Hill near Taiping, Malaya, from the rotten wood of an old tree, 4000 feet altitude (H. von Buttel-Reepen).

*Smithistruma* (*Smithistruma*) *dubia* new species

Pl. I, fig. 13

**Holotype worker:** TL 2.12, HL 0.52, WL 0.52, CI 80, MI 23. Head shape as described for the larger species of the *capitata* group as seen in dorsal view. Clypeus half as wide (width ca. 0.20 mm.) as the width across the occipital lobes. Head seen from side with dorsal profile strongly convex at the vertex and forming a nearly straight line anteriorly to the tips of the mandibles, the anterior part of the head in this view (with mandibles) enclosing an angle of about 40°. Median longitudinal sulcus and median depression of cephalic dorsum feeble and indistinct. Eyes as in the larger species, with about 6 facets in the greatest diameter, situated at about the midlength of the head on the dorsal side of the ventral scrobe border. Mandibles porrect, robust but somewhat depressed; relatively shorter than in the larger species. Dentition of a paratype shown in fig. 13; teeth nos. 1, 4 and 6 can be seen in the process of forming lamellate extensions of their borders so as to become rounded (compare with Pl. II, figs. 15, 17 and 20). The parallel development of this dentition shows the great difficulty one encounters in attempting to unravel phylogenetic lines among the higher dacetines. Antennal scape short (ca. 0.25 mm. long) and rather thick, bent at an angle of about 35° near its basal third, and beyond this incassate, thickest near midlength; funiculus ca. 0.39 mm. long, the apical segment accounting for half this length; segments I and IV nearly equal in length; both individually longer than II + III; III transverse, II not longer than broad.

Alitrunk robust, forming approximately equal, gentle and even promesonotal and propodeal convexities separated by a weak, shallowly concave depression of the extreme posterior mesonotum; metanotal groove feebly indicated at the posterior end of this depression. Pronotum with a sharp, broadly rounded anterior margin, without humeral angles, but humeral piligerous tubercles weakly developed. Promesonotal sutural line very feebly indicated, scarcely depressed. A rather coarse median longitudinal carinula extends the full length of the promesonotum. Propodeal teeth moderate in length, half or slightly more as long as the distance between the centers of their bases, laterally compressed, with apices strongly acute and curved feebly dorsad; infradental lamellae narrow but distinct, concave (following the sides of the declivity) and not sensibly broadened ventrally.

Petiole with a long, slender petiole, distinctly longer than the small subglobose node; the latter very slightly broader than long. A pair of faint carinules extend down the sides of the gentle anterior nodal slope and run onto the peduncle; posterolateral spongiform

lobes fairly broad, connected by a narrow posterodorsal collar; ventral longitudinal spongiform band fairly well developed. Postpetiole transversely elliptical, its disc strongly convex and very nearly twice as broad as long; nearly twice as broad as the petiolar node; its surface when clean smooth and shining, with a few weakly indicated short longitudinal striae or costulae along the extreme anterior border. Spongiform appendages quite voluminous and finely areolated ventrally; posterodorsal isthmus narrow, with a straight posterior border. Gaster "normal" in shape, only extremely slightly depressed dorsally, with an anteroventral pad and a thick transverse anterodorsal spongiform border. Basal costulae 15-17, short but distinct, extending only about  $1/6$  the length of the basal tergite; those in the middle even shorter. Gaster, like sides of posterior alitrunk and dorsal disc of postpetiole, smooth and shining. Body otherwise densely punctulate and opaque.

Ground pilosity of head and alitrunk consisting of sparsely arranged, small, whitish, subeclinate spatulate hairs. On clypeus, similar hairs more numerous and crowded, more easily seen, but still small and subappressed; those on the free clypeal border larger, somewhat spoon-shaped, 7-8 on each side of the midline, curving anteromedially, shortest in the middle anteriorly and forming a narrow fringe. Anterior scape border basad of bend with two broad spatulate hairs curved apically; bend with a longish spatulate hair curved basad, as is also the more slender hair next beyond; one or two smaller hairs beyond these, curved apicad. Dorsal surfaces of mandibles thickly set with small, appressed, linear squamose hairs. Six erect, weakly clavate hairs on the posterior dorsum of the head, arranged as described for the larger species; lateral occipital hairs (one on each side) slender, bristle-like, truncate at apices, a similar pair on the humeri; a single stout, erect spatulate hair on each side of the mesonotum. Petiolar node with small anterior and larger posterior spatulate pairs, inclined posteriorly, and the postpetiole with about six weakly clavate and spatulate hairs, similarly directed. Gastric dorsum with about 4 rows of 4 erect, weakly clavate hairs each, the anterior row situated at the posterior edge of the narrow band of basal costulae, inclined slightly anterior; second row near posterior border of basal tergite and directed posteriorly; a row each on the next two segments are also posteriorly inclined. Apex of gaster with a few weak tapered hairs. In general, the erect hairs are relatively shorter and less conspicuous than in the larger species of the group. Sting long, acute.

Color deep ferrugineous; mandibles and appendages slightly more yellowish.

Holotype worker [CMNH] taken in a log on the East Coast, Peleliu Island, Palau Group, southwestern Pacific Ocean, August 4, 1945 (H. S. Dybas).

*Paratypes:* A worker taken with the holotype (same date) and three other workers taken on Garakayo Island, Palau Group, August 6 and 8, 1945 (H. S. Dybas). Two of the Garakayo workers were taken together in leaf mould.

TL 1.91-2.14, HL 0.50-0.52, WL 0.50-0.53, CI 78-83, MI 21-24. Variation in color and other features negligible. Deposition in CMNH and MCZ.

*Gynotype female*, dealate: TL 2.48, HL 0.56, WL 0.62, CI 80, MI 24. Scutum with indistinct longitudinal rugulation. Petiolar node obliquely depressed from above and from the front; posterodorsal face about twice as broad as long, with a straight anterior border. Katepisternum and anteroventral lobe of anepisternum smooth and shining. Inner surfaces of ocellar calluses narrowly blackened; general body color deep ferrugineous. Allowing for normal differences of full sexuality, the female is very much like the worker.

Gynotype described from a solitary dealate female taken "under bark" on the East Coast, Peleliu Island, August 3, 1945 (H. S. Dybas); deposited in CMNH. Male unknown.

The records kept by Dybas indicate that this ant is at home in a relative variety of nest sites. It is very probably a tramp species originating from the larger Papuan or East Indian land masses to the south and west. I have named this species *dubia* because of the possibility that it is the same ant that Wheeler described under the name "*inez* subsp. *mumfordi*." According to Wheeler's puzzling and entirely inadequate description, *mumfordi* would differ from the present species in being much smaller still ("about 1 mm."), and in having the gastric dorsum shagreened. These would certainly seem to be adequate differences for separating the two forms, but Wheeler's descriptions are so often hopelessly inaccurate that the possibility of synonymy must be considered until someone has the opportunity to examine the *mumfordi* types.

## SMITHISTRUMA (SMITHISTRUMA) KARAWAJEWI (Brown)

*Strumigenys* (*Cephaloxys*) *emeryi* Karawajew, 1935, Treubia 15:106-108, fig. 25, female; not *Strumigenys emeryi* Mann, 1922. *Strumigenys* (*Trichoscapa*) *karawajewi* Brown, 1948, Ent. News 59:44, as nom. nov. *Smithistruma* (*Smithistruma*) *karawajewi* Brown, 1948, Trans. Amer. Ent. Soc. 74:105.

*Female*: I have not been able to examine a specimen of this ant, of which only the original specimen has been reported. Karawajew's original description and figures, however, seem to be good enough to place it as a distinct species close to those in the *capitata* group. The original description states of the length "with head outstretched scarcely more than 2 mm." If accurate, this would make the worker probably smaller than that of *dubia*. Head "1.23 times as long as broad," or, if converted to the terms used here, CI 81. Measurement of Karawajew's figure shows a CI of about 79, so we may perhaps assume that the original measurement and figure are fairly accurate. MI calculated from the figure 18-19, or distinctly less than in *dubia*. The postpetiole is described as "rather smooth and shining," and the figures show that this segment is quite similar in form to that of the female *dubia*. Clypeus as portrayed about as long as or slightly longer than broad, and the hairs on the free clypeal border a bit more prominent than in *dubia* or the larger species. The free clypeal border is also much more narrowly rounded than in *dubia*, *capitata*, etc., and the anterior part of the head more like that of *baudueri* than like any other Indo-Papuan species I have seen. The character that most impresses one as distinctive, however, is the pair of large, erect, apparently feebly spatulate hairs arising from the dorsum of the head a bit behind the level of the antennal insertions; the figure shows no other long hairs on the posterior part of the cephalic dorsum. While one might assume that the occipital hairs had once been present and have since been rubbed off, the middorsal pair is nevertheless in a position different to the erect hairs of any other *Smithistruma* known to me. Wings figured in the original description. In several respects, *karawajewi* seems as though it might be considered intermediate between the more typical members of the *capitata* group and those of the European *baudueri* group.

Known only from the supposed *type locality*: Siak, Sumatra (O. John). Present location of type unknown.

SMITHISTRUMA (SMITHISTRUMA) MUMFORDI (Wheeler) *nomen dubium*

*Strumigenys* (*Cephaloxys*) *inezi* [sic] subsp. *mumfordi* Wheeler, 1932, Bishop Mus. Bull. No. 98:160, worker.

*Worker*, original description in entirety: "Length about 1 mm. Even smaller than the variety *taipingensis* Forel from Malacca, but very similar in form and proportions. Erect club-shaped hairs on the abdomen longer; head covered with evenly-spaced, white, squamiform hairs, which are decidedly coarser than those on the clypeus. Gaster shagreened, only slightly shining, the basal half of the first segment dark brown."

Everything about this description is vague and confusing, and I am extremely doubtful about the accuracy of the total length given. On this occasion, Wheeler stated the comparison with *taipingensis* exactly as though he had a specimen of the latter before him at the time. However, there is every reason to believe that he had never seen a specimen of either *taipingensis* or *inezae*, for there are none in any existing part of his collection, and no further collections beyond the single type specimens of each of these forms have been reported. Even Forel did not have specimens in his collection! This comparison against an insect never seen was an unfortunate habit of Wheeler's that he by no means rarely executed.

The comparison, then, must have been again the description of *taipingensis*, but even this description is so very brief (and misleading in dimensions stated) that Wheeler could have gained not a grain of useful information from it. Scarcely more could have been gained from the description of *inezae*, which even now does not allow generic placement with complete certainty. From what is now known about *taipingensis* through Dr. Bischoff (see above), we cannot allow *mumfordi* to remain associated with it or with *inezae*. Unfortunately, I have not been able to examine the *mumfordi* types in the Bishop Museum at Honolulu due to the absence of the curator there. For the present, we cannot consider it certain that *mumfordi* is a *Smithistruma*, although Wheeler's description of the pilosity makes this seem likely.

*Type locality* (by present restriction): Hakahetau Valley, 2500 feet, Uapou, Marquesas Islands (A. M. Adamson), one worker.

An additional locality, one of the two original ones, is Ooumu, 4050 feet, Nukuhiva, Marquesas Islands (Mumford and Adamson), one worker.

#### KEY TO WORKERS OF SMITHISTRUMA\*

1. Head length without mandibles (HL) less than 0.55 mm. .... 2
- Head length without mandibles (HL) more than 0.55 mm. .... 3
2. Clypeus broader than long, its free border broadly rounded; occiput in undamaged specimens with 8 prominent outstanding hairs (Palau Is.; possibly a tramp species) ..... *dubia* n. sp.
- Clypeus not broader than long, its free border rather narrowly rounded; prominent erect hairs on dorsum of head apparently limited to a single pair situated slightly anterior to cephalic midlength (Sumatra) ..... *karawajewi* (Brown)
3. Propodeal dorsum in profile straight or very nearly so, continuing to the posterior depressed portion of the mesonotum without sensible interruption; long humeral hairs flagellate. See note at end of key ..... 4
- Propodeal dorsum in profile feebly convex; metanotal groove weakly but distinctly impressed below highest point reached by propodeum; humeral hairs stiff and narrowly spatulate at apices. See note at end of key ..... 5
4. Petiolar node slightly broader than long (Burma) ..... *dohertyi* (Emery)
- Petiolar node slightly longer than broad (Bornco) ..... *lamellignatha* n. sp.
5. Fifth hair from the base of the anterior scape border curved toward scape apex; MI usually slightly more than 25 (Philippines) ..... *pedunculata* n. sp.
- Fifth hair from base of the anterior scape border curved toward scape base; MI probably rarely more than 25 (E. New Guinea, etc.) ..... *capitata* (Fred. Smith)

Note: The species *inezae*, *taipingensis* and *mumfordi* are not included in the key because inadequately known. The first two species would probably key out to *lamellignatha*, from which they are both supposed to differ, according to the original descriptions, in having smooth and shining postpetiolar discs. For further information on these species and on *pedunculata* vs. *capitata*, see discussions in the text above. *Mumfordi* is also discussed in the text above; any small *Smithistruma* taken in the Polynesian islands may belong to Wheeler's species, which is inadequately described. *Capitata* and *karawajewi* are keyed from probable worker characters as deduced from the females.

#### SMITHISTRUMA S. STR. OF THE ETHIOPIAN REGION

##### EMARGINATA GROUP

To date, there are only four species of *Smithistruma* known from Africa south of the Sahara, and two of these are recently described as new. While very diverse in form, all of these species show apparent relationship to the *rostrata* group, and they are separated more on a geographical than a morphological basis from *rostrata* and its allies. The Ethiopian forms examined have rather fully and acutely dentate mandibles, and where the basal structure is clear, there is little or no trace of diastemation. The anterior clypeal border is transverse to very deeply emarginate.

The species *emarginata* and *cavinasis* are strongly aberrant and easily recognized. *Transversa* is known to me only through the original description, which is rather ambiguous concerning certain important features. *Truncatidens* is a more "typical" *Smithistruma*, but has a very distinctive basal mandibular lamella.

The relative scarcity of *Smithistruma* species in Africa appears to be due chiefly to the presence in the same region of the decidedly more ubiquitous and dominant forms of the genus *Serrastruma*. There are roughly 20 times as many records known to me for African *Serrastruma* as for *Smithistruma*,

\* This key applies to species of the Indo-Malayan, Papuan and Oceanian regions.

and I believe that this situation demonstrates less effective competition by the *Smithistruma* species in food-getting, the prey presumably being Collembola.

*Smithistruma* species may be distinguished from *Serrastruma* by the mandibles, which are shorter than the clypeus in the four known forms and which possess an armature of less than 15 teeth, all acute and not even in length, on the inner mandibular border.

SMITHISTRUMA (SMITHISTRUMA) EMARGINATA (Mayr)

Pl. 1, fig. 11

*Strumigenys emarginata* Mayr, 1901, Ann. Naturh. Hofmus., Wien 16:26-27, worker. *Strumigenys* (*Trichoscapa*) *emarginata* Santschi, 1913, Bull. Soc. Ent. France, p. 257, worker, in key. *Strumigenys emarginata* Arnold, 1917, Ann. S. Afr. Mus. 14:379, worker. *Strumigenys* (*Cephaloxys*) *emarginata* Emery, 1922, Gen. Ins. Fasc.: 174:324. *Smithistruma* (*Smithistruma*) *emarginata* Brown, Trans. Amer. Ent. Soc. 74:105.

**Worker:** TL 2.45-2.56, HL 0.63-0.68, WL 0.61-0.64, CI 59-62, MI 17-19, ICD 40-42. The long, very slender, depressed head was not emphasized by Mayr, except that he made a point of comparing the species with the almost equally narrow-headed *S. clypeata* of North America. The mandibles are rather prominent and broad, with dentition as in the figure. Labral lobes rather stout and incurved, the entire labrum a little longer than broad. Eyes rather large, elongate-oval and rather convex, 7-9 facets in the greatest diameter, slightly protruding at sides when the head is viewed en face. Dorsum of head very feebly impressed in the wide area between the vertex and the posterior clypeal border. Antennal scapes 0.33-0.35 mm. long, bent at about the basal third (ca. 30°), broadest just beyond the bend, where the anterior border is feebly subangulate. Funiculus 0.47-0.49 mm. long; apical segment slightly longer than I-IV taken together.

Pronotum narrow (average width 0.24 mm.); anterior pronotal margin nearly or completely obsolete; pronotal dorsum weakly substrate, appearing weakly submarginate laterally. Mesonotum subcircular seen from above, promesonotal sulcus weakly indicated. Mesonotum and remainder of alitrunk (except shining propodeal declivity) densely and finely punctulate. Propodeal teeth approximately as long as the distance between the centers of their bases, acute, the tips slightly upturned; infradental lamella thin and narrow, but slightly variable in development, narrowing gradually from the tooth downward.

Petiolear node about as long as its peduncle; fine carinate margins ascending the anterior face to form dorsolateral margins setting off the posterodorsal face as a disc; the disc about 0.11 mm. wide and approximately as long, with rounded anterior border, posteriorly slightly diverging lateral borders, and transverse posterior border. Postpetiolear disc much larger, convex dorsally and smooth and shining, free portion about 0.16 mm. long and 0.26 mm. wide. Spongiform appendages of both segments abundantly developed ventrally, moderately well developed posterolaterally; posterodorsal isthmus of postpetiole discontinuous in the middle, corresponding to a sulcus extending onto the anterior surface of the basal gastric tergite which causes the anterodorsal gastric border to be sinuate and almost completely divides the otherwise very well developed anterodorsal gastric spongiform margin. Basal costulae distinct, bilaterally grouped, spreading fan-wise from the spongiform mass on each side of the shallow sulcus, about 9 or 10 in each group and extending about half the length of the first tergite.

In the "typical" form, the erect bristle-like hairs are confined to the mesonotum and the tergites posterior to it, and to a small group of shorter ones on the posterior occiput. Dorsum of head with abundant short spoon-shaped hairs, mostly reclinate; similar but much sparser on the pronotum; clypeus with small, abundant, suborbicularly squamiform and appressed hairs, crowded, those on the free border rather uniform, only slightly shorter in the center, touching or overlapping one another; about 12-13 on each side of the midline. "Typical" form without extra-long specialized hairs on sides of occipital lobes or on humeri.

Color ferruginous yellow, varying only very slightly in the series seen.

The anterior clypeal emargination varies slightly in degree in my specimens, appearing nearly straight in workers such as one from Richards Bay. This specimen and another from the same colony also differ from Mayr's description and from the majority of workers from Natal and Southern Rhodesia in having more abundant stiff, erect hairs,

replacing the spoon-shaped ones not only on the propodeal dorsum, but also on the occiput and on the pronotum. Furthermore, the posterior half of the mesonotum and the propodeal dorsum form a single, very shallow concavity in these specimens. I should consider the Richards Bay specimens as a separate species were it not for the fact, even though my specimens are so few, that other series show apparent intergrades in all these characters. Variability is strongest in the Zululand specimens, and it may be that future specialists working in South Africa will be able to show northern and southern races meeting in the Zululand area not clearly indicated by the present series. The Richards Bay specimens possess weakly differentiated and somewhat elongate humeral hairs.

Female and male unknown. *Type locality*: Port Elizabeth (H. Brauns). Type in Mayr Coll.

*Material examined*: Bird Island, St. Lucia Lake, Zululand, 8 workers (J. C. Faure). Richards Bay, Zululand, 3 workers representing two colonies (J. C. Faure). Sawmills, Southern Rhodesia, 3 workers representing two colonies (G. Arnold, leg. et det.).

#### SMITHISTRUMA (SMITHISTRUMA) TRANSVERSA (Santschi)

*Strumigenys transversa* Santschi, 1913, Bull. Soc. Ent. France, pp. 257-258, worker, in key. *Strumigenys (Trichoscapa) transversa* Santschi, 1914, Medd. Göteborgs Mus. Zool. Afd. 3:31-32, fig. 6, worker. Arnold, 1917, Ann. S. Afr. Mus. 14:380, worker, (subgen. not cited). *Strumigenys (Cephaloxys) transversa* Emery, 1922, Gen. Ins. Fasc. 174:324. *Smithistruma (Smithistruma) transversa* Brown, 1948, Trans. Amer. Ent. Soc. 74:105.

*Worker*: Santschi differentiates this ant (which I have not seen) from *emarginata* on the basis of the straight anterior clypeal border and the "dark yellowish-brown" color. In view of the variability of the clypeal border noted above for *emarginata* and the inadequate description and figure Santschi gives, the characterization of this form and its differentiation from the sympatric *emarginata* must remain in doubt. From Santschi's figure, the head would show a cephalic index of about 70 and a mandibular index of about 23, but this conflicts slightly with his description, "Tete d'un quart plus long que large. . ." The mandibles are approximately  $\frac{3}{4}$  the length of the clypeus as shown in the figure, and seem from all the evidence presented by Santschi to be both relatively and absolutely larger and longer than those of *emarginata*. The figure shows a basal diastema of sorts, but I regard this representation as open to question. Only the worker is known; "Long. 2.2 mm." Type apparently in Santschi Coll.

*Type locality*: Pietermaritzburg, Natal (I. Traegaardh).

#### SMITHISTRUMA (SMITHISTRUMA) TRUNCATIDENS Brown

Pl. I, fig. 12

*Smithistruma (Smithistruma) truncatidens* Brown, 1950. Trans. Amer. Ent. Soc. 76:43-45, Pl. 3, fig. 1, worker.

*Holotype worker*: TL 2.36, HL 0.62, WL 0.64, CI 73, MI 14. Related to *S. emarginata*, but differing considerably in its more robust body build and especially by its broader, more "normal" head. Superficially, it resembles somewhat the Neotropical members of the *schulzi* group in general habitus, especially *S. orchibia* new species. Head with broadly expanded lateral occipital lobes, the latter not continued in outline by the preocular laminae, which are approximately parallel and very feebly convex. Clypeus subpentagonal, with the anterior border broadly and very shallowly emarginate and the anterolateral angles distinct but rounded; lateral clypeal borders weakly convex and moderately convergent anteriorly; clypeal surface approximately plane, with a small, inconspicuous anteromedian tumulus. The anterior clypeal emargination is weaker than in most specimens of *emarginata*, but stronger than in *rostrata*; these three species forming a close series in this respect. Maximum width of the clypeus approximately half the greatest width across the occipital lobes, and the disc slightly broader than long. Dorsum of head between vertex and posterior clypeal border approximately plane, appearing very slightly depressed in profile view; the vertex forming an obtuse rounded angle. ICD about 46. Eyes a little smaller than in *emarginata*, more nearly round, just barely protruding at the sides when head is viewed en face; each with 6-7 facets in the greatest diameter, placed slightly behind the cephalic midlength.

Antennal scape 0.29 mm. long, bent at an angle of about 40° near the basal third;



rather broadly incrassate, not quite so broadly as in *studiosi*, but a bit more so than in *margaritae* among the Neotropical species, broadest just distal to the bend; anterior border straight basally to bend, where it forms a rounded obtuse angle, beyond which it is gently convex until the extreme apex of the scape, which is narrowed and curved slightly anteriorly. Funiculus 0.42 mm. long, the apical segment accounting for more than half the length; basal segment (I) slightly longer than IV; IV about as long as II + III, but much thicker; III appearing (at 60X) slightly broader than long; II about as broad as long.

Mandibles in place and closed resembling those of *S. rostrata*, but not relatively so long, the toothing rather coarse and occupying the entire visible inner borders. The figure will show the peculiar truncate, blade-like basal lamella so characteristic of this species and for which I have coined the name *truncatidens*.

Pronotum somewhat depressed dorsally; in profile extremely feebly convex and sloping anteriorly; mesonotum gently convex in front, anteriorly and laterally with very feeble margins or carinae; promesonotal sulcus faintly indicated. Anterior pronotal margin seen from above entire, but not very sharp, passing through gentle humeral curves into the sides and forming with them a major segment of a slightly lengthened circle. Posterior half of mesonotum narrowed and depressed, nearly continuous posteriorly with the propodeal dorsum, the latter very slightly elevated above the level of the posterior mesonotum and feebly convex. Metanotal groove obsolescent, barely discernible as a line. Propodeal teeth acute, with rather broad bases; moderately divergent and about 2/3 as long as their interbasal distance; infradental lamellae low, even, translucent, almost cariniform, following the concavity of the steeply sloping propodeal declivity.

Petiolar node broader than long and shorter than its peduncle; anterior face sloping rather steeply, summit narrowly rounded seen from the side. Cariniform margins of face of node suppressed, not evident. Both posterior collar and ventral strip of spongiform tissue present, but moderately developed. Postpetiole transversely oval, about 1.4 times as broad as the petiolar node and about 1.3 times as broad as long; disc strongly convex, appearing superficially to be smooth and shining, but at higher magnifications seen to be obscurely and very feebly longitudinally striate its length. Postpetiolar spongiform appendages fairly well developed posterolaterally and ventrally, the posterodorsal isthmus very poorly developed and interrupted in the middle. Gaster with weakly depressed dorsum; anterodorsal spongiform margin well developed. First gastric tergite not sulcate anteromedially, but the middle costulae more or less effaced. In spite of this medial gap, the costulae remaining on each side are not "bilaterally grouped" in the sense that they radiate from two common centers; instead, they are parallel, about 20 in number, and extend longitudinally about 1/2 the length of the basal tergite. Remainder of gastric dorsum smooth or nearly smooth and shining, but with a few very feebly roughened areas that may represent foreign material or a secretion. Sculpture of body of the usual *Smithistruma* pattern, except that the pronotum has very obscure longitudinal substriation superimposed on the usual dense, fine punctulation; posterior sides of alitrunk partially smooth and shining.

Head dorsally with rather abundant but inconspicuous, subreclinate to subappressed, short spoon-shaped hairs, a few on the posterior and lateral borders of the occipital region a little longer, more nearly clavate, and obliquely suberect. Hairs on clypeal disc few, extremely small, scale-like, not usually visible at all except in good light at magnifications of 50-60X; hairs on free clypeal border much larger, spoon-shaped and curved toward the middle, about 12 on each side of the midline, forming a fringe much like that of *rostrata*, except that the hairs on the anterolateral corners, while largest, are not so greatly lengthened relative to the lengths of the neighboring hairs on the border; also, the bordering hairs are all much broader than in *rostrata*. The alitrunk has very few and inconspicuous small, narrow reclinate hairs on the dorsum, but these so small that special pains must be taken in order to view them even at higher magnifications. No prominent hairs on the humeri; possibly rubbed off, but not present in paratypes. A pair of conspicuous, erect, feebly clavate hairs on the mesonotum. Petiolar node with a pair of long, stiff, subclavate hairs, directed posteriorly; postpetiole with about 8 moderately long subclavate erect hairs; gaster with about 6 transverse rows of 3-4 feebly clavate, stiffly erect hairs each. Anterior scape border with distinctive hair pattern; the hairs long, linear-spatulate, all curved slightly toward the base except the most basal one (no. 1), which is curved weakly apically; the hair on the anterior angle at the bend much the longest, distinctly longer than



the greatest width of the scape itself. Pilosity of legs very sparse and inconspicuous, consisting of small, narrow reclinate hairs.

Color dull yellowish-ferrugineous.

Holotype one of a series of 4 workers taken at Lupembe, Tanganyika (K. Bock); deposited in Consani Coll.

*Paratypes:* The three remaining workers from the type series, taken with the holotype, show only very slight variation. TL 2.35-2.43, HL 0.62, WL 0.63-0.65, CI 72-73, MI 14-15. In the largest specimen, the head is very faintly infuscated posteriorly. [Consani Coll., MCZ]

Signor Consani has also sent a specimen taken by S. Patrizi at Elmenteita, Kenya Colony. TL 2.81, HL 0.69, WL 0.74, CI 73, MI 14. Entire body larger than in the types of *truncatidens*. Substriation of pronotum and postpetiole a little stronger, but still obscure. Gastric costulae extending quite half the length of gastric tergite I, rest of this tergite appearing feebly and superficially but densely shagreened and subopaque. Small suberect spatulate hairs, one on each humerus. Color medium ferrugineous, slightly but distinctly darker than in *truncatidens* types.

Signor Consani believes that this specimen represents a new species, and he may be right. However, the differences are so slight that I do not feel inspired to credit this single specimen as representative of a species distinct from *truncatidens*. In expressing this opinion, I have kept in mind the variability in pilosity of the closely related species, *S. emarginata*, and also the fact that very little is known about variation in other African *Smithistruma*. The material available for *truncatidens* is so scanty, representing only one colony and this single doubtful stray, that I consider it wiser to wait for additional material. If the stray is doubtfully distinct, there is even less justification for calling it a sub-species under modern systematic principles, and no justification whatever for calling it a "variety."

#### SMITHISTRUMA (SMITHISTRUMA) CAVINASIS Brown

*Smithistruma (Smithistruma) cavinasis* Brown, 1950, Trans. Amer. Ent. Soc. 76:42-43, worker.

*Holotype worker:* TL 2.01, HL 0.55, WL 0.50, CI 63, MI 7 (low MI due both to small size of mandibles and to the partial recession in the deep anterior clypeal excision).

Head shape of *rostrata* group, most like that of *conspecta* Emery, but with very shallowly concave posterior occipital border and clypeus deeply and semicircularly excised anteriorly. Cephalic dorsum convex posteriorly, impressed posterior to clypeus. Clypeus weakly convex, only slightly broader than long, lateral borders convergent and very feebly convex. Eyes moderate in size, placed very slightly behind the cephalic midlength and rather far ventrad; not visible from dorsal view of head. Antennal scape sharply bent at about its basal quarter and thickest at the bend; anterior border at this point forming nearly a right angle; exposed scape length about 0.25 mm. Funiculus about 0.34 mm. long, apical segment  $1\frac{1}{2}$  times as long as the remaining funicular segments taken together; segment I much longer than IV; IV as broad or slightly broader than long and slightly longer than II + III, II about as broad as long; III shorter, transverse.

Mandibles very small, closed, their bases received into the clypeal excision (dorsal view) and their depressed blades converging. Dentition uninterrupted along the visible portions of the inner borders, consisting of fine, slender acute teeth, the principal series apparently numbering five, with two smaller ones just basal to the preapical denticulae; the latter and the apical tooth could not be seen distinctly in this specimen due to the complete closure of the mandibles. Since the specimen is a unique, no dissection could be made to determine the structure of the basal lamella. No diastema seen, but it is not known whether one might be present hidden under the clypeal shield.

Alitrunk feebly depressed; pronotum without humeral angles or tubercles and not distinctly marginate laterally. In profile, dorsum of alitrunk forming one continuous weakly convex outline; metanotal groove virtually obsolete. Propodeal teeth short, triangular, acute, subtended ventrally by very slight infradental lamellae gradually diminishing to weak carinulae at ventral extremities. Petiole with node rounded above and about equal to the slender peduncle in length; a fine lamelliform carinula on each side, extending up the anterior nodal slope to the summit. Postpetiole broad (width about 0.30 mm.) and very convex, approximately twice as broad as the petiolar node. Both nodes with voluminous ventral and lateral spongiform masses. Gaster more strongly convex ventrally

than dorsally, with a heavy anterodorsal transverse border of spongiform tissue. Basal gastric costulae delicate but distinct, well separated and parallel, with feeble reticulation intervening; extending about 1/3 the length of the basal tergite. Remainder of gaster and dorsum of postpetiole smooth and shining.

Alitrunk feebly and indistinctly reticulate-punctulate, appearing somewhat subopaque except for promesonotal dorsum, which is finely and rather irregularly longitudinally striate or rugulose. Head, scapes, legs and petiole densely punctulate and opaque.

Ground pilosity consisting of comparatively few (very few on alitrunk) conspicuous, whitish-yellow, thickened and suborbicularly broadened squamose hairs set close to the integumental surface, but not strictly appressed; more crowded, flatter, and slightly smaller on the clypeal surface; the excision bordered by six of these hairs, three on each side, and the dorsal surfaces of the scapes with a row near the anterior border. Longer spatulate hairs, about 6 on each lateral clypeal border and 8 on the anterior border of each scape, where all but the last three nearest the apex are directed sharply basad. Base of first gastric tergite with a single pair of short, erect, mesially inclined clavate hairs; posterior half of the same tergite with a few scattered short, appressed simple hairs. Apical region of gaster with a few short, fine erect clavate hairs. No specialized erect hairs on head or alitrunk of this specimen.

Color sordid yellowish-ferrugineous.

Holotype a unique collected during February 1948, Beni-Irumu, Ituri Forest, Belgian Congo (N. A. Weber, cat. no. 2129); to be returned to Dr. Weber for eventual deposition in AMNH.

This is a very distinct and bizarre species, differing from the known African species (and from all others known to me) in the extremely small mandibles, shallow posterior occipital excision and very deep anterior clypeal excision. The large, heavy, disc-like hairs are also developed to a degree unique among the species I have seen. The hairs fringing the free clypeal border are so arranged as to heighten the effects of clypeal excision and mandibular recession, and the apices of the hairs form a deep semicircle framing the mandibles on three sides. The longest hairs on the anterolateral lobe-like projections formed by the deep median excision extend forward almost as far as do the mandibles themselves. The clypeal excision is easily the strongest and deepest known for any species of *Smithistruma* known. *Cavinasis* appears to be a very extreme development of the *rostrata* line in the Ethiopian Region, and it is related to the other species of this line here treated as the *emarginata* group. Furthermore, *cavinasis* shows many similarities to the two African species of *Micostruma*, small forms with the funicular segments reduced to three in number.

#### KEY TO THE WORKERS OF SMITHISTRUMA S. STR.\*

1. Clypeus with a very deep anterior semicircular excision; mandibles very small, partly recessed in the excision (MI 7); clypeal hairs very broadly suborbicular and conspicuous; size small, TL under 2.10 mm. (Congo) ..... *cavinasis* Brown
- Clypeus transverse or shallowly and broadly emarginate anteriorly; mandibles larger, projecting (MI well over 10); clypeal hairs not broadly suborbicular; size larger, TL over 2.10 mm. .... 2
2. Head very long and narrow (CI under 65), depressed; mandibular dentition as in figure 11 (eastern South Africa) ..... *emarginata* (Mayr)
- Head broader (CI over 65) ..... 3
3. Anterior clypeal border gently emarginate; prominent erect hairs on alitrunk at most two pairs; MI under 20; mandibular dentition as in fig. 12 (British East Africa) ..... *truncatidens* Brown
- Anterior clypeal border straight (teste Santschi); numerous prominent erect hairs on alitrunk; MI over 20; mandibular dentition in doubt, see discussion in text (eastern South Africa) ..... *transversa* (Santschi)

#### SMITHISTRUMA OF THE PALEARCTIC REGION

The Palearctic Region contains two distinct faunas. The Sino-Japanese fauna contains two known species belonging to the *rostrata* group; these have

\* This key applies to species of the Ethiopian Region.

been described in Part I of the present revision (Mushi, XX, pp. 10-14, 1949). These two species are *incerta* and *rostrataeformis*. The older species *japonica* is presently removed from *Smithistruma* to *Weberistruma*, so that all doubts as to the validity of *incerta* are considered dissipated.

#### BAUDUERI GROUP

The Mediterranean fauna contains *baudueri* and two forms which seem to differ from the typical *baudueri* in the form of the cephalic pilosity. There is no doubt as to what the typical *baudueri* is; Emery has described it well enough and figured it rather completely in his work of 1916 (loc. cit. infra); only a few additional points of interest are offered below. The trouble comes with two variants having narrowed cephalic pilosity, one in which the hairs are elongate and rather slender, but still with distinctly spatulate apices (on the clypeus), and the other with even finer pilosity, that of the clypeus with no apical flattening, or at least no flattening discernible at a magnification of about 85X.

One of these forms undoubtedly corresponds to Emery's variety *tenuipilis*, but I cannot say with certainty which should bear this name because of Emery's ambiguous original statement. The chances appear great that the form with some slight broadening of the clypeal hairs is *tenuipilis*, because I have such specimens from northern Italy, and the original localities are Monte Argentario (here restricted as type locality) and "southern France," whereas the form with extremely fine pilosity is from Corfu. These pilosity forms correspond in a rough way to the series *clypeata-pilinis-laevis* of North America, and Emery's statement regarding *tenuipilis*, "The var. *pilinis* For. of *S. clypeata* Rog. differs from the type species by the same character," is perhaps to be regarded as additional evidence that *tenuipilis* is represented by the "intermediate" form.

The problem of designating these forms as species, subspecies or mere non-taxonomic variants is a trying one, and the solution presented here is to be regarded as completely tentative, open best to investigation by European workers on the spot. Since the variation appears to be constant in the known material, and since the evidence for the broad allopatry of the three forms is not at all convincing, I believe that these forms must be considered as specifically distinct in a provisional sense. The form from Corfu is named as a new species, *tenuissima*, with the hope that Mediterranean specialists will test it thoroughly on the basis of modern population systematics. Should clear intergrades be found to link the three *baudueri* group forms, synonymy of both *tenuipilis* and *tenuissima* would be indicated, and furthermore, light would be shed on the possible relationships within the *clypeata* group. It must be emphasized that these three forms differ in no discernible character of marked significance except that of pilosity.

#### SMITHISTRUMA (SMITHISTRUMA) BAUDUERI (Emery)

Pl. II, fig. 25

*Epiritus baudueri* Emery, 1875, Ann. Mus. Civ. Stor. Nat., Genova 7:474, fig., female. *Strumigenys baudueri* Emery, 1887, Ann. Mus. Civ. Stor. Nat., Genova 25:468, footnote. *Strumigenys normandi* Santschi, 1910, Bull. Soc. Hist. Nat. Afr. Nord 1:71, fig., worker. (Reference not seen) *Strumigenys (Trichoscapa) baudueri* var. *normandi*

Santschi, 1913, Bull. Soc. Ent. France, p. 258, worker, in key. *Strumigenys* (*Cephaloxys*) *baudueri* Emery, 1916, Bull. Soc. Ent. Ital. 47:204-206, figs. 61, 62, worker, female, male. 1922, Gen. Ins. Fasc. 174:323 (see for further early references). Bondroit, 1918, Ann. Soc. Ent. France 87:168, fig. 82, all castes. *Strumigenys bauderi* [sic] Menozzi, 1928, Boll. Lab. Zool. Ist. Agr. Portici 21:128, male, biology. *Strumigenys baudieri* [sic] Stiller, 1937, Ent. Nachrichtenblatt 11:175, biology. (Other European authors have used this name spelled as Stiller has it. These references, which are records mostly from the Adriatic littoral, are not cited here because they add little to the general knowledge of this ant.)

*Worker*: 24 specimens, representing about 10 colonies, from Hungary, Dalmatia, vicinity of Trieste, Italy, etc. TL 1.86-2.09, HL 0.54-0.58, CI 67-72, MI 15-18. Emery has described and figured this ant rather well in his work of 1916 (loc. cit.), and special attention is drawn to his figure 61b, which shows the typical clypeal pilosity. The hairs on the cephalic dorsum posterior to the clypeus are short and more or less spoon-shaped, becoming longer and narrower on the occiput. Propodeal dorsum and declivity most often shining, as are the dorsal surfaces of both nodes and the greater part of the pronotal dorsum. Head cuneiform, the sides and preocular laminae converging and forming straight, continuous outlines to the mandibular apices. The surface of the clypeus varying from subopaque to opaque.

*Female*: Based on a single female from Florence (Andreini), TL 2.28, HL 0.60, CI 70, MI 13. Emery gives the total length of the female as 2.3 mm., which checks very well with my measurements; however, his measurements of the worker ("2.2-3 mm.") average greater than mine. I very much doubt that the worker ever gets as large as the female.

*Male*: I have seen no male specimens. Emery's description of a male (1916) assigned with doubt to this species has been verified by Menozzi, who found males associated with workers and compared them with Emery's allotype; he declared his specimens identical to that of Emery.

*Type locality*: Sos, southern France (Bauduer). Type in Emery Coll.

#### MATERIAL EXAMINED

HUNGARY: Szeged (V. Stiller).

ITALY, DALMATIA, ETC.: Trieste (Springer); Liserta (Tasso, Schatzmeyer and Koch); Scurac (Novak); Zemonico (G. Müller, B. Finzi); Lucca (A. Andreini); Florence (A. Andreini); Genoa (Solari); S. Viot, Modena (Emilia); Genoa (Mantero). A few other specimens from northern and central Italian localities were too badly depilated to afford certain determinations. Emery cites as localities Pantelleria, Corsica, Sardinia, Tunisia, South of France and Constantinople; *baudueri* is apparently widespread in the Mediterranean region, but I consider it at least possible that some of these records may refer to one or both of the other forms discussed here. Emery synonymized Santschi's species *normandi* from North Africa; Santschi himself had earlier lowered this form to the status of a variety. I have not seen the *normandi* types, but the future European reviser of this group should test the synonymy thoroughly.

#### SMITHISTRUMA (SMITHISTRUMA) TENUIPILIS (Emery)

*Strumigenys baudueri* var. *tenuipilis* Emery, 1915, Ann. Mus. Civ. Stor. Nat., Genova 46:264, worker. *Strumigenys* (*Cephaloxys*) *baudueri* var. *tenuipilis* Emery, 1916, Bull. Soc. Ent. Ital. 47:205, worker. Bondroit, 1918, Ann. Soc. Ent. France 87:168. Emery, 1922, Gen. Ins. Fasc. 174:323.

*Worker*: I refer to this species three specimens from Cadenabbia, Como, Lombardia (G. Binaghi) in the Finzi Collection. The clypeal hairs are decidedly more slender and elongate than those of *baudueri*, distinctly raised in an arch away from the surface of the clypeal disc and curving anteriorly and mesially. The apices of the hairs are seen to be narrowly spatulate at magnifications of 60X and more. The hairs of the remainder of the cephalic dorsum are longer and more filiform than those of *baudueri*. Emery's original description is as follows in translation:

"... differing from all the other examples of *baudueri* I have seen in that the clypeal hairs are not squamously dilated, and for this reason do not appear as white points." I have already noted his comparison to *S. pilinasis* in the discussion above. The size, proportions and other characteristics as in *baudueri*.

*Type locality:* Monte Argentario (by present restriction). Other original locality was stated merely as "southern France." Types in Emery Coll.

***Smithistruma (Smithistruma) tenuissima* new species**

*Holotype worker:* Size and proportions as in *S. baudueri* and *S. tenuipilis*. Clypeal pilosity abundant but very fine and filiform, the apices appearing truncate, or in some cases even slightly tapered, at a magnification of 85X; the hairs arched curved weakly mesially. The thickness of the individual hairs appears similar to that shown in the figure of *S. flitalpa* (Pl. 1, fig. 8). The anterior half of the clypeal disc weakly shining, posterior half subopaque. Hairs on upper (posterior) cephalic dorsum very fine and filiform, more so than in the Lombardian specimens referred to *tenuipilis*. Mesonotum with slightly irregular, spaced longitudinal rugulae, these stronger than in any other specimens of the *baudueri* group I have seen to date, but since the rugulae are more or less weakly developed in all *baudueri* specimens, this feature may perhaps be discounted. Otherwise as in *baudueri* and *tenuipilis* in all discernible details.

Holotype a unique taken at Gasturi, Corfu (Beier), in Finzi Coll. deposited in MCZ. Prof. Finzi had this specimen set off separately in his collection, but under the specimens bearing the general label "*baudueri*." I describe the form as a species (with some misgivings) in the hope that its recognition as a separate form will stimulate collection of and research upon the *Smithistruma* of southern Europe. I stand ready to compare specimens or give any needed information concerning the type, which I fully realize may ultimately have to be considered as a synonym, together with *tenuipilis*, of a very variable *baudueri*.

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## PLATES

All plate figures, with exception of figures 6, 8 and 9, were drawn with the aid of a camera lucida from specimens mounted in damar, using the high dry objective of a standard microscope and 10X oculars. Figures 6, 8 and 9 were drawn with the aid of a squared ocular disc and a stereoscopic microscope. The inking of Plates I and II was accomplished by Mr. F. Y. Cheng, who also did figures 34-38 on Plate III. Others on Plate III were inked by Mr. W. L. Nutting or myself. All original pencil drawings are by the author. Most of the figures are at best only very roughly to scale.

## PLATE I

Figs. 1-14. *Smithistruma* workers unless stated otherwise.—1. *S. creightoni* (M. R. Smith), left mandible, ventral view. Nidotypic specimen. 2. *S. ornata* (Mayr), left mandible, ventral view, showing adventitious tooth as dashed line. Composite drawing. 3. *S. abdita* (L. and R. Wesson), left mandible, ventral view. Gibraltar Island, Ohio. 4. *S. ohioensis* (Kennedy and Schramm), left mandible of male, ventral view. Knoxville, Tennessee. 5. *S. talpa* (Weber), left mandible of male, dorsal view. Knoxville, Tennessee. 6. *S. bunki* Brown, clypeal outline. Paratype, Slidell, Louisiana. 7. *S. missouriensis* (M. R. Smith), right mandible, ventral view. South-central Ohio. 8. *S. filialpa* Brown, clypeal outline. Holotype. 9. *S. wrayi* Brown, clypeal outline. Holotype. 10. *S. bunki* Brown, right mandible, ventral view. Paratype, Landon, Mississippi. 11. *S. emarginata* (Mayr), right mandible, dorsal view. St. Lucia Lake, Zululand. 12. *S. truncatidens* Brown, left mandible, dorsal view. Paratype, Lupembe, Tanganyika. 13. *S. dubia* n. sp., left mandible, ventral view. Paratype, Garakayo I, Palau Group. 14. *S. pedunculata* n. sp., right mandible, ventral view. Paratype, Negros Or., Philippines.

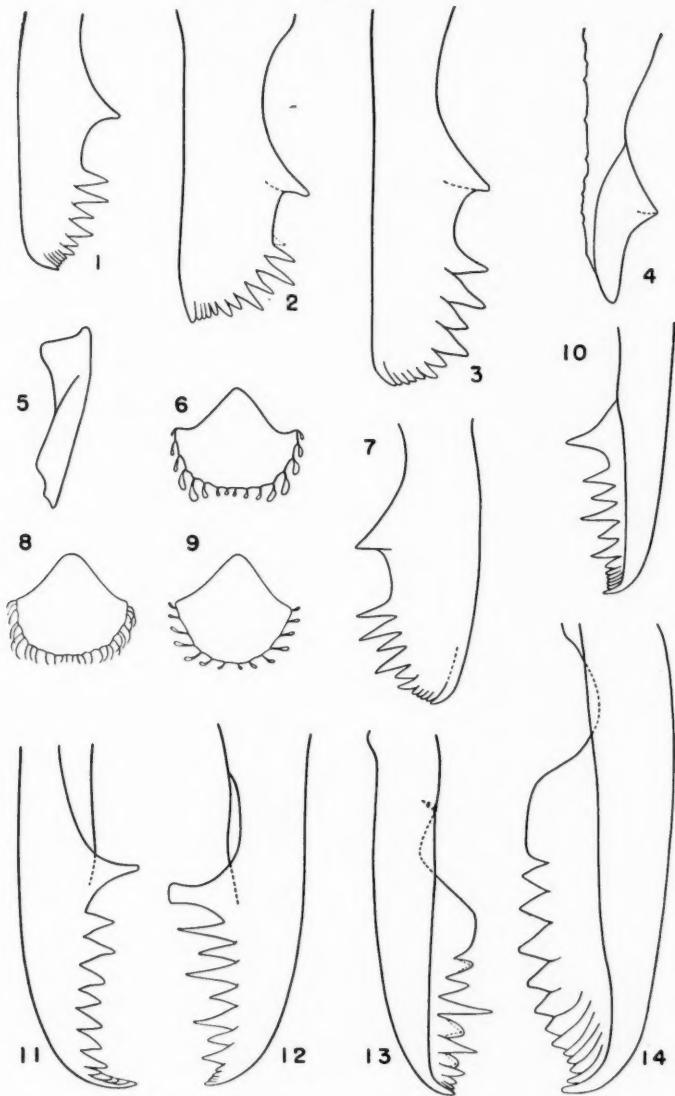
## PLATE II

Figs. 15-26. *Smithistruma*, Mandibles of workers.—15. *S. nigrescens* (Wheeler), left, ventral view. Mina Carlota, Cuba. 16. *S. clypeata* (Roger), left, ventral view, showing adventitious tooth as dashed line. Composite. 17. *S. alberti* (Forel), right, dorsal view. Laudet, Dominica, B. W. I. 18. *S. (Platystroma) depressiceps* (Weber), left, ventral view. Cotype, Kartabo, British Guiana. 19. *S. ohioensis* (Kennedy and Schramm), left, dorsal view. South-central Ohio. 20. *S. margaritae* (Forel), right, ventral view. New Braunfels, Texas. 21. *S. friderici-mülleri*, left, dorsal view. Cotype, Itajahy, Brazil. 22. *S. alegrensis* n. sp., left, mesial view. Paratype, Porto Alegre, Brazil. 23. *S. epinotalis* (Weber), right, ventral view. Cotype of *S. skwarrae* (syn.), Mirador, Vera Cruz. 24. *S. orchibia* n. sp., left, dorsal view. Paratype, Venezuela. 25. *S. baudueri* (Emery), left, ventral view. Genoa, Italy. 26. *S. rostrata* (Emery), left, ventral view. Newport News, Virginia.

## PLATE III

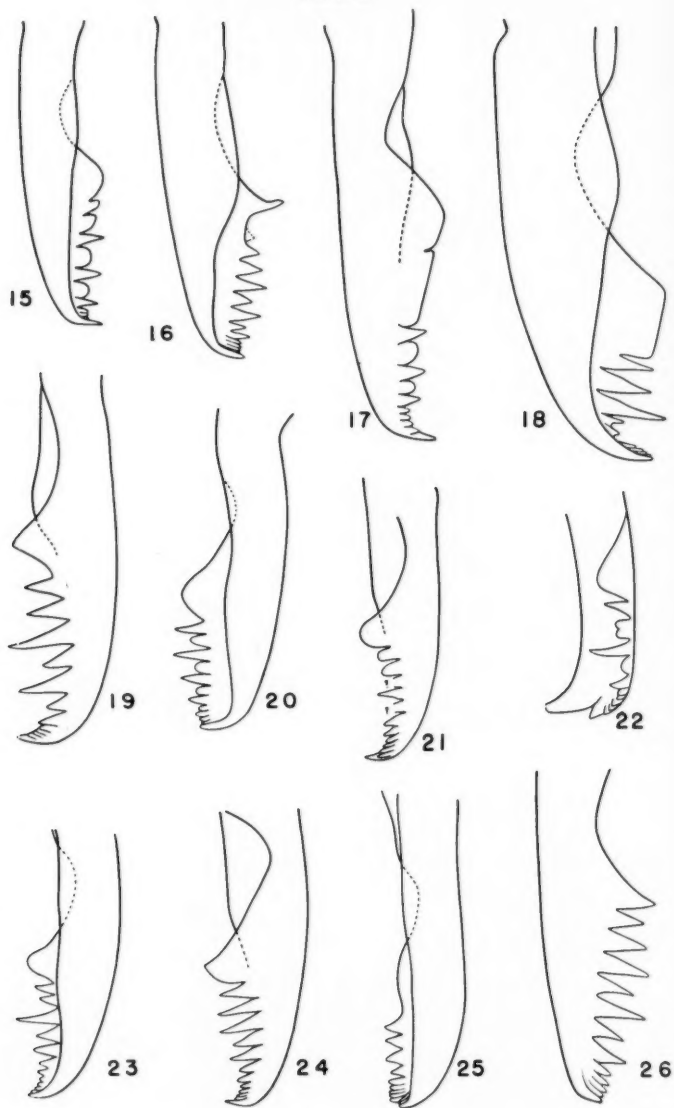
Figs. 27-38. *Smithistruma*.—27-33. Volsellae of males: 27. *S. alberti* (Forel). Laudet, Dominica, B. W. I. 28. *S. rostrata* (Emery). South-central Ohio. 29. *S. (Wessonistruma) pergandei* (Emery). South-central Ohio. 30. *S. ohioensis* (Kennedy and Schramm). Knoxville, Tennessee. 31. *S. talpa* (Weber). Knoxville, Tennessee. 33. *S. lamellignatha* n. sp. Alloparatype, Mt. Tibang, N. Borneo. 32-38. Mandibles of various genera: 32. *Smithistruma rostrata* (Emery), male, left, dorsal view. South-central Ohio. 34. *Tingimyrax mirabilis* Mann, worker, right, dorsal view. Cotype. 35. *Strumigenys (Pyramica) gundlachi* Roger, mesial view, tip of mandible shown in fig. 38. 36. *Neostruma* sp., mesial view, tip of mandible shown in fig. 37. 37. *Neostruma* sp., worker, left, dorsal view. Barro Colorado I, Canal Zone. 38. *Str. (P.) gundlachi*, worker, left, dorsal view. Soledad, Limones Seboruco, Cuba.

## PLATE I

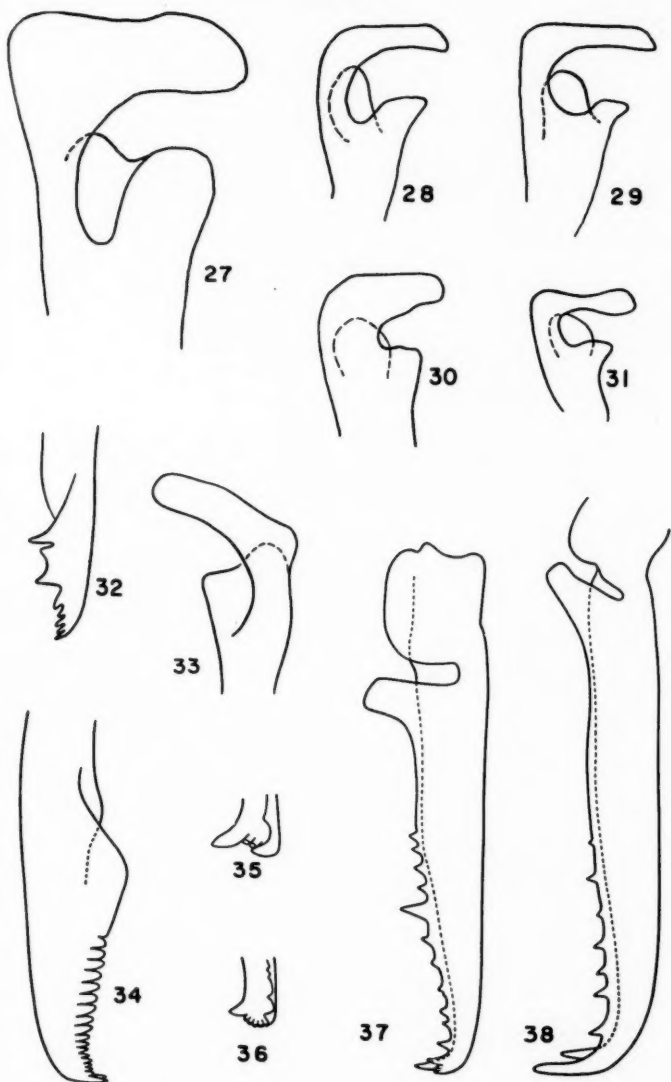




## PLATE II



## PLATE III



# Some American Millipeds of the Order Spirobolida

Ralph V. Chamberlin  
University of Utah, Salt Lake City

The records and descriptions of millipeds given in the present paper are based upon specimens of the order Spirobolida in the diplopod collections of the Chicago Natural History Museum, where all types are deposited. These specimens came chiefly from the southern United States and Middle America and were collected for the most part by Dr. Karl P. Schmidt and Henry Dybas of that museum. I am very appreciative to Dr. Schmidt for the privilege of studying this collection and for the attention he has given in the course of field work to a much neglected group of animals.

## Family ATOPETHOLIDAE

### ATOPETHOLUS ANGELUS Chamberlin

*Atopetholus angelus* Chamberlin, 1920, Proc. Biol. Soc. Wash. 33:101.

*Locality*.—CALIFORNIA: Los Angeles, Reservoir Hill. One specimen taken in 1916 by Gordon Grant.

### ATOPETHOLUS CALIFORNICUS Chamberlin

*Atopetholus californicus* Chamberlin, 1918, Proc. Biol. Soc. Wash. 31:168.

*Locality*.—CALIFORNIA: Los Angeles. Many specimens taken on Dec. 22, 1935; Jan. 5, Mar. 1-15, and Dec. 15, 1936; and Nov. 6, 1938. Most collected by Gordon Grant.

## Family RHINOCRICIDAE

### ARTIFICIAL KEY TO GENERA AS REPRESENTED

- |  |                      |
|--|----------------------|
| 1. Sensory cones of antennae numerous .....  | 2                    |
| Sensory cones of antennae invariably 4 .....   | 5                    |
| 2. Scobina absent .....  | <i>Metacricus</i>    |
| Scobina present .....  | 3                    |
| 3. Anal tergite with a long, distally more or less upturned cauda; branches of posterior gonopods both slender ..... | <i>Neocricus</i>     |
| Anal tergite not caudate, surpassed by the valves; one branch of posterior gonopods laminate .....                   | <i>Rhinocricus</i>   |
| 5. Scobina present .....   | <i>Eurhinocricus</i> |
| Scobina absent .....   | <i>Lissocricus</i>   |

### *Eurhinocricus barrios* n. sp.

General color of body olivaceous, with brownish annuli about the metazonites; anal tergite, excepting its caudal border, dark, but anal valves entirely yellowish; collum dark, with narrow light borders; head dark excepting the lighter clypeal area, but antennae pale; legs light ferruginous.

Head lightly coriariouly roughened above, smoother below; median sulcus distinct. Clypeal setae 2 + 2.

On the ordinary rings the segmental sulcus is distinct throughout; it closely embraces the pore on each side. Prozonites marked with conspicuous oblique striae on the sides, these becoming transverse across dorsum. The metazonites smoother than the prozonites. Scobina with anterior pits deep and wide, separated by twice their width, or but little more; striate area posteriorly very narrow.

Anal tergite with caudal portion triangular, the apex not free. Anal valves with inner borders compressed and protruding. Anal scale triangular, its caudal angle a little rounded.

Gonopods as represented in figs. 11 and 12.

Number of segments, 43.

Width, 2.2 mm.

*Locality*.—GUATEMALA: Escobas, opposite Point Barrios. Two males taken Apr. 19, 1934 by K. P. Schmidt (Leon Mandel Expedition).

**Eurhinocricus incursor n. sp.**

Body black throughout, the band behind sulcus on most segments more chestnut but sometimes also black, the whole appearing black to the naked eye. Legs and antennae also black, or in part dusky chestnut. Vertigial sulcus interrupted as usual near the antennal level; surface of head irregularly rugose in area of interruption and over vertex; sulcus weak and on lower part of face vague or absent. Clypeal foveolae 1+1.

Collum well rounded about lateral ends, margined below and anteriorly as usual but without other sulci or markings.

On the ordinary segments the encircling furrow distinct throughout but the sulcus in the furrow more sharply impressed on the sides than across dorsum; sulcus not excurved at the pore to which it is tangent. Longitudinal striae of the metazonite present only ventrally, the remaining part of segment essentially smooth and shining. Scobina with an anterior pit absent or obsolete, the striae areas elliptic in outline and very widely separated.

Triangular caudal portion of the anal tergite set off by a distinct transverse furrow. Anal valves with mesal borders compressed and elevated. Anal scale triangular.

Number of segments, 52.

Width, 9.8-10 mm.

*Locality*.—HAITI: Cape Haitien. Two females taken Dec. 6, 1928 by K. P. Schmidt.

Separated from the other known Haitian species by the character of the scobina and its black color.

**Eurhinocricus chichivac n. sp.**

Figs. 1, 2

Greyish brown with narrow but strongly marked annuli on the caudal borders of the segments; anal segment entirely light colored; collum with reddish borders; head having a somewhat orange cast. Legs and antennae light brown or somewhat yellowish.

Clypeal foveolae 2+2. Head smooth and shining.

Collum widely rounded at ends; narrowly margined laterally and up the front; surface smooth and shining.

The ordinary segments characterized by having the primary sulcus clearly impressed; a distinct secondary sulcus in front of the primary one. Scobina with anterior pits small and but weakly impressed, striate area with sides convex, the area widest behind; lunate pits separated by about five times their width.

Anal tergite posteriorly narrowed into a cauda which surpasses the valves and is a little decurved. Valves with mesal borders moderately protruding. Anal scale with caudal margin on each side widely and gently concave, their junction form an obtuse median angle.

Coxae of legs 3-5 in the male with an acute laminate process, those of the fifth small.

Gonopods as drawn (Figs. 1, 2).

Number of segments, 50.

Width, 3 mm.

*Locality*.—GUATEMALA: Chichivac, near Tecpan. One male taken by F. J. W. Schmidt on Feb. 1, 1934.

**Eurhinocricus eutypus n. sp.**

Figs. 21, 22

Conspicuously annulate, there being on each segment a broader anterior band of dark brown, mottled with yellow, the band more solid across dorsum, and posteriorly a paler submarginal band; anal segment black; collum mottled; head clear yellowish or of slightly orange cast. Legs and antennae yellowish or of slightly orange tinge.

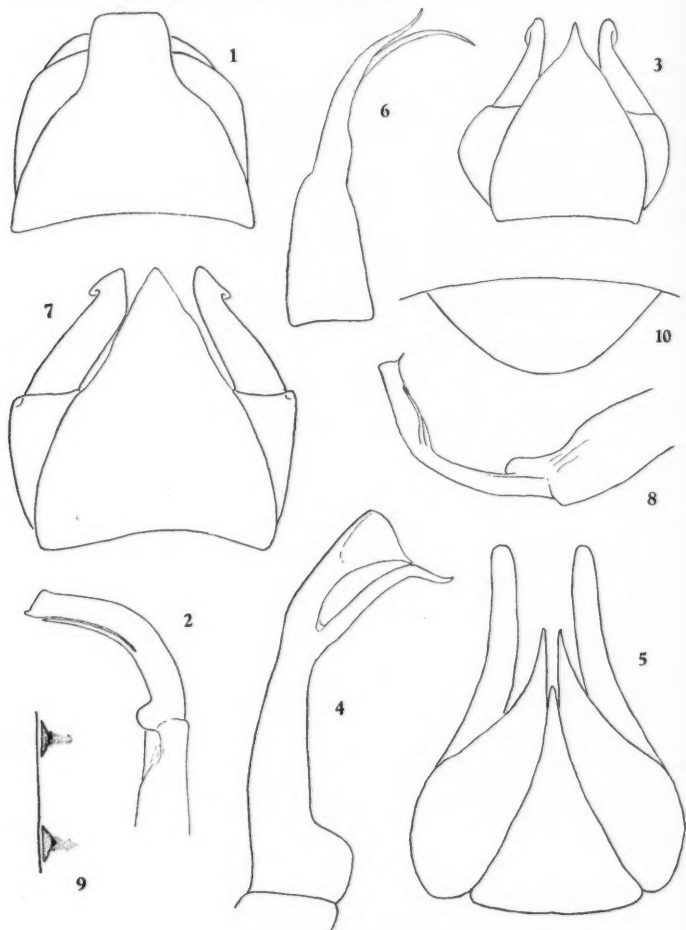
Clypeal setae 2+2. Median sulcus of head distinct, with the usual interantennal interruption. Surface in general appearing smooth and shining.

Collum with ends widely rounded, margined as usual but with no other sculpturing.

On the ordinary segments the primary sulcus seems obsolete across dorsum where

replaced by the distinct secondary sulcus. Prozonites with the usual oblique striae below and the metazonites with the normal series of longitudinal striae below.

Anal scutum narrowed into a free cauda that surpasses the valves and is distally a little decurved. Anal scale convexly rounded caudally.



Figs. 1-10.—1. *Eurhinocricus chichivacus* n. sp. Anterior gonopods, cephalic aspect; 2. The same. A posterior gonopod; 3. *Metacricus modestus* n. sp. Anterior gonopods, cephalic aspect; 4. The same. Left posterior gonopod, distal segment, on larger scale; 5. *Neocricus ireneei* n. sp. Anterior gonopods, anterior aspect; 6. The same. Posterior gonopod; 7. *Oxypyge curticaudus* n. sp. Anterior gonopods, cephalic aspect; 8. The same. Posterior gonopod; 9. *Rhinocricus calius* n. sp. Scobina; 10. The same. Anal scale.

Coxae of legs 3-5 with the typical processes, these decreasing in size from those of the third pair to those of the fifth.

Gonopods as represented in figs. 21 and 22.

Number of segments, 49.

Width, 2.4 mm.

*Locality*.—GUATEMALA: Volcan Tajumulco. One male and three females taken Feb. 21, 1934, by K. P. Schmidt (Mandel Expedition).

#### *Lissocricus* n. gen.

Millipeds of small size characterized by lacking scobina, having only four sensory cones on the antennae, and having the anal tergite caudate and prominently surpassing the anal valves.

*Type*.—*Lissocricus howlandi* n. sp.

While the important characters provided by the male are not at present known, it is believed that this well marked species can be readily recognized and that the correlated features of scobina, antennae and anal tergite will serve tentatively for generic definition.

#### *Lissocricus howlandi* n. sp.

Prozonites mostly brown, the narrower metazonites lighter and thus presenting definite annuli. Last segment entirely orange colored. Collum also orange or somewhat chestnut. Head the same, with the face of a duller or somewhat dusky cast. Legs and antennae yellow.

Median sulcus of head sharply impressed across vertex and down to labrum excepting the usual interantennal interruption. Clypeal foveolae  $2 + 2$ . Antennae short, with four terminal sensory cones. Ocelli in four transverse, moderately curved series; e.g., 6, 6, 5, 3.

Collum with ends strongly rounded, much exceeded below by the second tergite; narrowly margined below and up the anterior side.

On the ordinary segments the sulcus is deeply impressed throughout; sulcus sub-tangent to the pore lying immediately in front of it, moderately angled at its level. Prozonites with a very fine but distinct stria across dorsum and part way down sides near edge of the overlapping preceding metazonite, but otherwise free or nearly so of other cross striae. Metazonites shown longitudinal striae only beneath. Surface in general appearing smooth and shining.

Anal tergite abruptly narrowed into a distinct, cylindrical and straight cauda which prominently surpasses the valves. Anal valves smooth, with inner borders moderately compressed and raised. Anal scale subtriangular.

Number of segments, 45.

Width, 3.2 mm.

*Locality*.—COLOMBIA: near Santa Marta and Margarita. One female taken in July-August, 1902, by H. W. Howland.

#### *Metacricus* n. gen.

Antennae bearing numerous sensory cones as in *Rhinocricus* but differing from that genus in lacking scobina and in having the anal tergite surpassing the anal valves, the projecting part or cauda laminate. Anal valves mesally compressed and elevated. Sternite of anterior gonopods ending in an acute apex which is nearly on a level with the tips of the telopodites. Posterior gonopods of general form similar to that of *Rhinocricus*.

*Type*.—*Metacricus modestus* n. sp.

#### *Metacricus modestus* n. sp.

Body, including collum and anal segment, olive grey with a narrow caudal border on each annulus darker, black or nearly so. Legs and antennae cinnamon brown.

Median sulcus of head with the usual interantennal interruption; with some coriaceous markings above, smoother below. Clypeal foveolae  $2 + 2$ .

Collum without sulci excepting the usual margining one below and up front.

On the ordinary segments the sulcus single and complete, very fine across dorsum, coarser on sides, narrowly excurved above pore. Prozonites without encircling striae, the metazonites with the usual longitudinal sulci beneath. No scobina evident.

Anal tergite distally triangular, exceeding the valves, narrowly rounded at tip. Anal

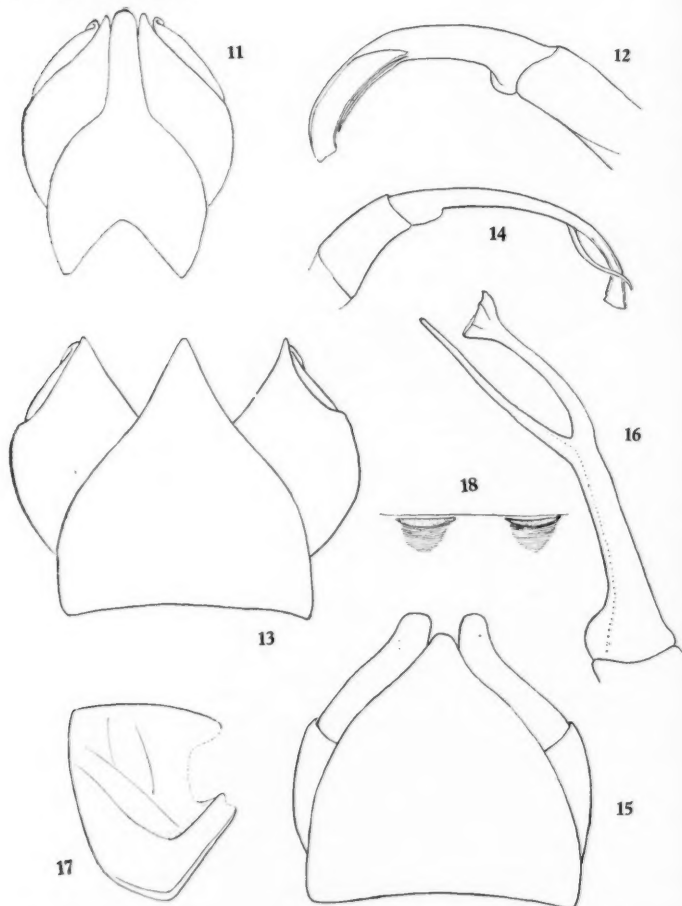
scale with posterior median angle obtuse. Inner borders of valves strongly elevated.

Gonopods as shown in figs. 3 and 4.

Number of segments, 42.

Width of male, 5 mm.; of female, 6 mm.

Locality.—VENEZUELA: probably near Caracas. One male and one female taken May 7 by Hermano Irene.



Figs. 11-18.—11. *Eurhinocricus barrios* n. sp. Anterior gonopods, cephalic aspect; 12. The same. A posterior gonopod; 13. *Rhinocricus chichen* n. sp. Anterior gonopods, cephalic aspect; 14. The same. Posterior gonopod; 15. *Rhinocricus mas* n. sp. Anterior gonopods, cephalic aspect; 16. The same. Posterior gonopod; 17. *Rhinocricus melanior* n. sp. Collum, anterior portion broken off, lateral aspect; 18. The same. Scabina.



*Neocricus ireneei* n. sp.

Segments dull chestnut behind the sulcus, bluish grey in front, the anal segment entirely bluish grey; collum with all borders chestnut; head chestnut. Legs yellowish, the antennae slightly darker.

Collum with a curved furrow on each side above lower end, some wavy striae below and above this and irregularly over caudal border.

Segmental sulcus of ordinary segments distinct down the sides, but across dorsum very fine, though complete, and easily confused among the numerous striae. Prozonites closely striate with transverse striae which are wavy, broken and in part anastomosing; similar striae on the metazonite, these transverse in middorsal region but lower down above and below the pore becoming oblique, below this running nearly longitudinally and continuing the series of the usual striae beneath. Pore contiguous with segmental sulcus. Scobina consisting of the usual lunate pit in front, followed by a rather elongate area of fine, close-set striae; those of anterior and middle segments about  $2\frac{1}{2}$  times the width of the lunate impression apart.

Gonopods as represented in figs. 5 and 6.

Width, 9 mm.

*Locality*.—VENEZUELA: probably near Caracas. One male taken by Hermano Irene on May 8 (year uncertain).

Apparently nearest to *N. foederatus* Chamb., from which it may be distinguished superficially in color pattern, in that in *foederatus* the chestnut color extends over the prozonites, although somewhat lighter there, as well as over the metazonites. In *foederatus* the scobina are smaller and much more widely separated, with the striate area narrower and more pointed behind.

*Oxygye curticaudus* n. sp.

Segments black or somewhat brownish black behind the sulcus, the dark stripe narrowing down the sides and ending ventrally; similarly colored immediately in front of the sulcus but there not extending below level of pores, the remaining part of prozonite and the ventral region yellow. Anal segment dark. Head yellow, with a dusky, H-shaped mark on face, the lower arms much longer than the upper. Antennae and legs yellow.

Eyes subcircular in outline, widely separated. Clypeal setae 2 + 2.

Collum with ends widely rounded; a submarginal sulcus below but none in front; surface smooth.

On typical segments the sulcus is sharply impressed throughout. Pore nearly contiguous with the sulcus which is slightly excurved at its level. Tergites smooth and shining, the longitudinal striae on the metazonites fine, few in number, and present only below. Prozonites without transverse striae above. Scobina with anterior pits about three times their width apart; the striate area rounded behind.

Anal tergite narrowed posteriorly into a slender caudal portion which does not surpass the valves. Anal valves with the spine or tooth at upper angle short and bluntly rounded. Anal scale triangular, but with the caudal angle well rounded.

Gonopods as shown in figs. 7 and 8.

Number of segments, 51.

Width of male, 2.2 mm.; of female, 3.5 mm.

*Locality*.—GUATEMALA: Bobos River, Izabal. A male and three females taken Dec. 15, 1933, by K. P. Schmidt (Mandel Expedition).

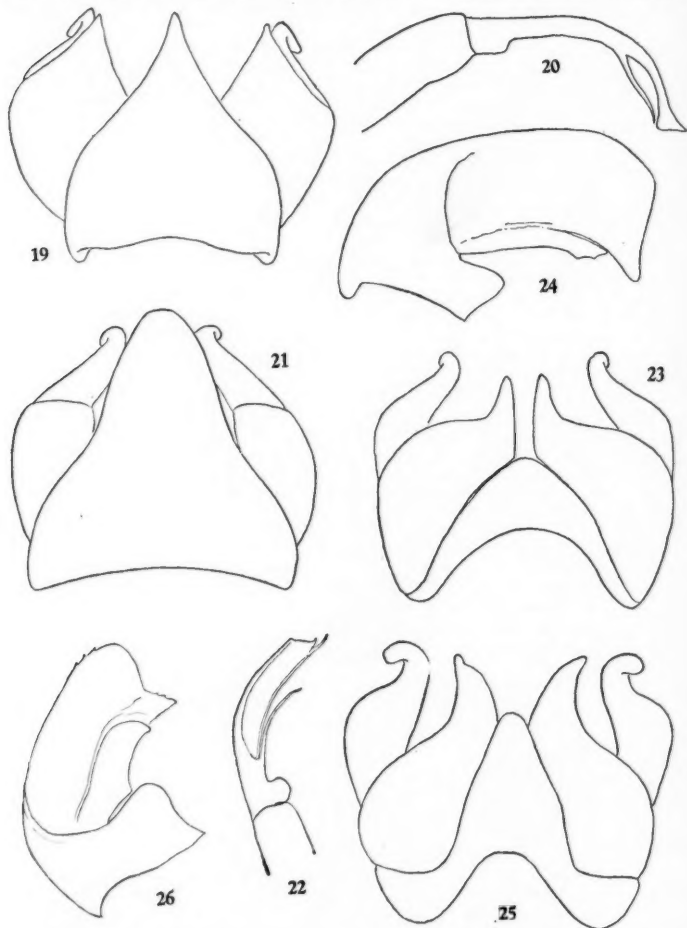
*Rhinocricus calinus* n. sp.

Body conspicuously annulate, the exposed part of the prozonites being olive and the metazonites brown. Anal tergite olive, with the caudal border brown or somewhat chestnut. Anal valves brown with mesal borders brownish. Borders of collum brown, the rest olive. Head olivaceous excepting the lighter clypeal area. Legs pale ferruginous, the antennae brown.

Head essentially smooth, the vertex under the microscope showing an irregular network of very fine lines. Clypeal foveolae 2 + 2. Sensory cones of antennae numerous as usual.

Collum with lower ends widely rounded; narrowly margined below and up the anterior border; two rather short, longitudinal striae above each lower border.

Ordinary segments with both the primary and a secondary sulcus clearly impressed. Metazonite with deep longitudinal sulci, the series continuing entirely across dorsum. Striae of prozonites as usual, these strongly developed. Scobina with anterior pits separated by about twice their transverse width; striate area pointed behind with the sides



Figs. 19-26.—19. *Rhinocricus tejerianus* n. sp. Anterior gonopods, cephalic aspect; 20. The same. Posterior gonopod; 21. *Eurhinocricus eutypus* n. sp. Anterior gonopods, cephalic aspect; 22. The same. Posterior gonopod; 23. *Aztecocolus fratrellus* n. sp. Anterior gonopods, cephalic aspect; 24. *Aztecocolus fratrellus* n. sp. Posterior gonopod; 25. *Rhinocricus vulcan* n. sp. Anterior gonopods, cephalic aspect; 26. The same. Posterior gonopod.

incurved, the area as a whole relatively narrow (Fig. 9).

Last tergite with caudal angle narrowly rounded, exceeded by the valves. Anal scale as a whole semicircular, the caudal and lateral angles together forming an evenly convex curve (See fig. 10).

Number of segments, 45.

Width, 6.4 mm.

*Locality*.—COLOMBIA: Cali. One female taken by H. Dybas June 30, 1937.

While based upon a female, this species should be readily recognized by the presence of the series of longitudinal sulci entirely across dorsum as well as down the sides and beneath.

#### **Rhinocricus chichen n. sp.**

Color olive, with narrow annuli of brown along caudal borders of segments; collum olive, with anterior and posterior borders brown. Head and antennae olive. Legs chestnut.

Head smooth and shining, the median sulcus distinct throughout except the usual interantennal interruption. Eyes with ocelli in six longitudinal, gently curved series; thus, 1, 3, 5, 6, 6, 6. Clypeal setae 2 + 2.

Collum smooth, without special sulci other than the margining one.

On the ordinary body segments the segmental sulcus is complete, obtusely angled at level of pore with which it is continuous. Under the microscope the surface appears finely and densely puncto-rugose. Anterior band of prozonite set off by a deep sulcus in front of which the surface is coriarius. On the under side the prozonites with oblique striae and the metazonites with typical longitudinal striae, the series of the latter not extending up the sides. Scobina with submarginal pits deep, scarcely more than their width apart; striate area very small.

Anal tergite with tip rounded, the margin each side of it gently concave; not free, exceeded by the valves. Anal scale broadly triangular, its caudal angle obtuse, with margin each side concave. Valves with inner borders compressed and protruding.

Gonopods as shown in figs. 13 and 14.

Number of segments, 48.

Width, 11 mm.

*Locality*.—YUCATAN: Chichen Itza. Two males and a female taken by E. A. Andrews, 1933-34.

#### **Rhinocricus mas n. sp.**

Body olivaceous, with a narrow annulus of brown over caudal border of each segment; last segment, collum and head also olive colored, the clypeal border and a line down middle of head pale; legs and antennae ferruginous.

Median sulcus of head sharply impressed, with the usual interruption. Clypeal setae 2 + 2.

Collum narrowly margined below and about anterior corner only, with no other sulci, the surface smooth and shining.

On the ordinary body rings the segmental sulcus is distinct throughout; embracing the pore on its posterior side. The usual fine longitudinal striae on metazonite beneath, the surface otherwise smooth except under magnification which reveals the usual coriarius pattern. Scobina with the anterior pits wide but almost slit-like, the striate area behind it narrow and short, broadly lunate in outline; on anterior segments the pits separated by less than their transverse width.

The anal tergite with posterior end triangular, the tip rounded, not free, exceeded by the valves. Valves with mesal borders compressed and raised. Anal scale subtriangular, the caudal angle rounded.

Gonopods as represented in figs 15 and 16.

Number of segments, 52.

Width, 7 mm.

*Locality*.—BRAZIL: Therezopolis. One male taken July 9, 1926 (Marshall Field Expedition).

#### **Rhinocricus melanior n. sp.**

Body a uniform black throughout, without annuli or other light markings. Legs and antennae ferruginous.

Vertex of head coriarius marked; median sulcus fine, running forward through a

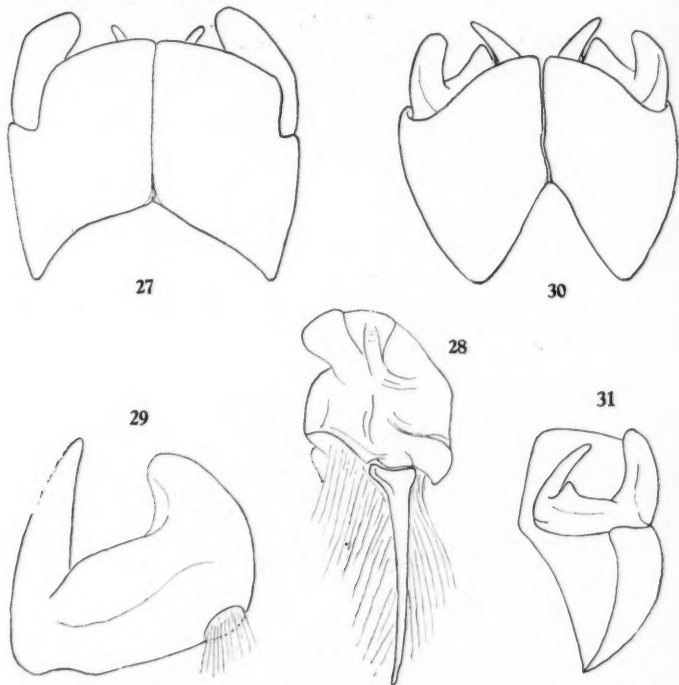
depression in interantennal area below which it is interrupted. Clypeal foveolae normal in number.

The collum with anterior margin straight over middle portion; above the somewhat thickened lower portion on each side two oblique sulci, the lower of these limiting a border area which in anterior part is elevated; mesad of the upper of these two oblique striae are two transverse striae. Caudal margin nearly straight over middle portion (See fig. 17).

On the ordinary segments the primary sulcus is obsolete dorsally, its position there marked by a series of short, mostly curved and obliquely placed striae. A secondary sulcus distinctly impressed over dorsum and down to level of the pores. Prozonite with the usual striation, the striae below level of pores running obliquely as usual. Series of longitudinal striae on the metazonites continuous up to the pore on each side. Dorsal surface of metatergites crossed by a series of low but distinct rugae which are absent only from a narrow median area. Scobina large, the anterior pits wide transversely, the two separated by their width (Fig. 18).

Anal tergite in dorsal view subtriangular, the caudal end narrowly rounded, not free, surpassed by the valves. Anal valves mesally compressed and elevated in the usual way. Anal scale in outline broadly subtriangular but caudally widely rounded.

Number of segments, 49.



Figs. 27-31.—27. *Schmidtolus chichivacus* n. sp. Anterior gonopods, anterior view; 28. The same. Right posterior gonopod, caudal view; 29. The same. Telopodite of anterior gonopod, caudal aspect; 30. *Schmidtolus parvior* n. sp. Anterior gonopods, cephalic aspect; 31. The same. Left anterior gonopod, caudal aspect.

Width, 11 mm.

*Locality*.—COLOMBIA: Cali. One female taken by H. Dybas, June 30, 1937.

While the male of this species is not known, there should be little difficulty in recognizing this large form from its size, color, scobina and especially the collum with its peculiarly thickened lower border and the sulci above it as shown in fig. 17.

*RHINOCRICUS POTOSIANUS* Chamberlin

*Rhinocricus potosianus* Chamberlin, 1941, Ent. News, 52:252.

*Locality*.—MEXICO: San Luis Potosi; Tamazunchale. One not fully mature female taken June 19, 1941 by H. Dybas.

Previously known from Xelitle in the same state.

*Rhinocricus relictus* n. sp.

Color of body in general brown, the metazonites more deeply colored, a darker brown than the light brown prozonites. Legs light ferruginous, the antennae somewhat darker.

Head lightly coriariouly roughened above. Median sulcus in a shallow furrow across vertex, widely interrupted in the interantennal area. Clypeal foveolae 2 + 2. Sensory cones of antennae numerous as typical.

Anterior corners of collum subrectangular in outline but the angle rounded; posterior corners widely rounded off; anterior margin across middle portion straight, the corresponding part of the posterior margin slightly incurved. No definite striae on collum excepting the usual margining sulcus.

On typical segments the primary sulcus is complete but is less deeply impressed across dorsum than a secondary sulcus in front of it; a series of short oblique striae between the two sulci across dorsum. Striation of prozonites normal. Metazonites with the normal striae on sides and beneath but these not present on dorsum where there are some low, irregular rugae which are most distinct toward caudal margin. Scobina large, the lunate depressions separated by a little more than their width; striate area large, narrowing caudad, the caudal end rounded and sides straight or nearly so. Caudal margin of each metazonite sinuous above scobina of the following segment.

Caudal tergite narrowly rounded behind, exceeded by the valves. Mesal borders of valves compressed and elevated. Anal scale well rounded behind.

Number of segments, 46.

Width, 7 mm.

*Locality*.—COLOMBIA: Cali. Two females taken by H. Dybas on June 30, 1937.

*Rhinocricus tejerianus* n. sp.

Figs. 19, 20

Body somewhat chocolate colored with caudal border of metazonites bright chestnut or reddish; head, with antennae, collum and last tergite dark chocolate colored. Legs dark chocolate to nearly black.

Median sulcus of head deeply impressed. Head coriariouly above. In the types there is but a single clypeal seta on each side, but a slight foveola at the lower margin may represent the position of a second one.

Collum margined in the usual manner but without other sulci; surface puncto-coriariouly marked.

On the ordinary segments the sulcus is fine below level of the pore and obsolete or very difficult to trace across dorsum. Longitudinal sulci of metazonites present only ventrally. Scobina represented by a deep submarginal lunate impression or pit with behind it a striate area that is narrow and short, the striae very fine.

The anal tergite triangularly narrowed behind with the end rounded and not free, being exceeded by the valves. Anal valves mesally compressed as usual. Anal scale widely rounded posteriorly.

Gonopods as represented in figs. 19 and 20.

Number of segments, 49.

Width, 9 mm.

*Locality*.—MEXICO: Vera Cruz, Tejeria. Two males taken by H. Dybas on July 4, 1941.

Family SPIROBOLIDAE  
*Aztecocolus collaris* n. sp.

Exposed part of the prozonites solid black above, black mottled with yellow on the sides, the black embracing also the anterior part of each metazonite dorsally, the metazonites otherwise light brown or yellowish; collum black bordered with the lighter color; last tergite black, narrowly bordered with yellow behind; anal valves black; head black excepting the lighter clypeal area. Legs and antennae yellowish.

Clypeal setae  $3+3$ , with the outer one on each side more widely removed from the inner one than the two inner ones are from each other. Median sulcus of head fine but distinct. Head smooth and shining throughout.

Collum of the typical general form, being acutely narrowed down each side, with the ends narrowly rounded and exceeded below by the second tergite; margined up the front on each side; the surface otherwise smooth and shining.

Segmental sulcus on typical segments fine but distinct throughout; tangent to the pore. Prozonites with encircling striae of which the most anterior is deeper and more pronounced than the others; the striae curving back to the sulcus on lower part of the sides. Longitudinal striae present on the metazonites below, the series not extending up on the sides.

Anal scutum short as usual and much exceeded by the valves; caudally obtuse with the median angle rounded, with the margin on each side a little concave. Anal valves mesally compressed and protruding as usual. Anal scale wide, with caudal margin forming a very obtuse angle at middle, gently concave each side of angle.

Number of segments, 39-40.

Diameter, 6.5 mm.

*Locality*.—GUATEMALA: Volcan Tajumulco. Two females taken by K. P. Schmidt on Feb. 21, 1934 (Mandel Expedition).

This conspicuously marked species is referred to *Aztecocolus* necessarily with some doubt in the absence of a male; but the agreement in general features of the structure with that genus is such that this disposition is probably correct. There should be no difficulty in recognizing the species because of its strongly marked color pattern.

*Aztecocolus fratrellus* n. sp.

Figs. 23, 24

Color dull yellow, with a narrow brown stripe along caudal border and another one at the sulcus of each segment; collum yellow over middle portion, with a broad brown border all around; anal scutum brownish yellow, the valves a lighter yellow. Legs ferruginous yellow and the antennae brown.

Clypeal setae  $3+3$ .

Collum strongly narrowed down the sides, the ends narrowly rounded, slightly exceeded below by the second tergite.

Sulcus on ordinary segments distinct, contiguous with pore as usual exposed portion of segments coriariouly roughened above. Prozonites with the covered part striate transversely, the striae down the sides bending back obliquely as usual. Series of striae on the metazonites not extending up to pore by a wide distance.

Anal tergite obtusely angled behind as in *vulcan*; much exceeded by the valves. Anal scale subtrapeziform but the caudal margin not quite straight but forming a very obtuse angle at the middle. Anal valves with mesal borders compressed as usual.

Gonopods as represented in figs. 23 and 24.

Number of segments, 38.

Width, 2.2 mm.

*Locality*.—GUATEMALA: Volcan Tajumulco. One male taken Feb. 18, 1934 by K. P. Schmidt.

*Aztecocolus vulcan* n. sp.

General color brown a black or dusky band in front of sulcus on each segment, this interrupted above with result of a series of lighter areas along the dorsum, the dark band fading out ventrally and above tending to spread onto the prozonite, especially on the anterior segments; collum and vertex of head blackish. Legs brown, the antennae reddish or chestnut.

Clypeal foveolae  $3+3$ . Eyes rotund, widely separated. Surface of head in general smooth and shining.

Collum acutely narrowed down each side; exceeded below by the second tergite; margined up the anterior sides; surface appearing puncto-rugose under the microscope.

Segmental sulcus on ordinary segments complete. Surface of segments in front of sulcus puncto-rugose, smoother behind sulcus. Prozonites with transverse striae above, these running obliquely on the sides as usual; the more anterior ones above deeper and more widely separated than the others; longitudinal striae on metazonites absent from upper part of sides.

Anal tergite obtusely angled behind, the tip not free, surpassed by the valves. Anal valves mesally compressed as usual. Anal scale with caudal margin at middle forming a very obtuse angle.

Gonopods as represented in figs. 25 and 26.

Number of segments, 39-40.

Width of male, 4 mm.; of female, 4.8 mm.

Locality.—GUATEMALA: Volcan Tajumulco. One male, one female and one partly grown taken by K. P. Schmidt on Feb. 18, 1934 (Mandel Expedition).

#### MICROSPIROBOLUS SIGILLATUS Loomis

*Microsporobolus sigillatus* Loomis, 1934, Smith. Miscell. Collections: 89(14)20.

Locality.—HAITI: Christophes Citadel, near Cape Haitien, at El. 2,800 ft. A male and female taken by K. P. Schmidt, Dec. 5, 1928 (Crane Field Museum Pacific Expedition of 1928-29).

The type location for the species was Morne, Pilboreau. It has also been previously taken by Loomis from the Citadel.

#### Schmidtolus n. gen.

Related most closely to *Messicobolus* which it resembles in having the anterior sternite of the gonopods abortive or absent, and in the expanded, mesally contiguous pieces of the anterior gonopods. It differs in not having these coxal plates produced at the meso-distal corners, and, more importantly, in the enlarged, transversely placed telopodites of the anterior gonopods which are subcontinuous with each other at the median line where each is produced distad in a cornuate process. Posterior gonopods short and thick, rather weakly sclerotized, supported by a long basal stalk with axis in the same line. Clypeal foveolae  $3+3$  to  $5+5$ . Coxae of legs 3 to 5 in the male with ventral processes. The anterior legs of male conspicuously crassate.

Type.—*Schmidtolus chichivacus* n. sp.

The known species of this genus are much smaller than those of *Messicobolus*.

#### Schmidtolus chichivacus n. sp.

Figs. 27-29

A darker form than *prior*; nearly black above, but with a patch of yellow mottling above each pore; a similar mottling down the anterior border of each metazonite; venter pale ferruginous, a color that tends to spread up the lower portion of the sides. Anal segment black. Collum with a network of dark lines over a light background; borders black, the anterior and posterior black bands widened at the middle line. Head light, with a network of dark lines over vertex and lateral parts of front, with a dark band between eyes which sends diverging branches down the face and enclosing light dots as in *prior*. Legs pale ferruginous, the antennae dusky.

Eyes subcircular, widely separated. Clypeal setae  $5+5$ .

Wings of the collum extending below level of the immediately following tergites, the ends strongly rounded.

On the ordinary segments the encircling furrow is well marked and smooth, not interrupted by a series of punctae such as are present in the next species.

Anal tergite smooth, rounded behind where free for a short distance. Anal valves smooth and without compressed or elevated mesal borders. Anal scale with free margin arcuate, the median section strongly convex, the lateral sections incurved.

In the male the second to fifth pairs of legs bear subconical processes on the coxae; the first pair of legs not especially crassate but the second to fifth legs have the three



proximal joints strongly crassate, legs of the sixth and seventh pairs less enlarged.

The gonopods very similar to those of *prior*, but distal piece of the anterior pair without the conical process ectad of the inner cornuate process (See figs. 27 and 29).

Number of segments, 39-41.

Width, 2 mm.

*Locality*.—GUATEMALA: Sta. Elena, near Tecpan. Four specimens taken by K. P. Schmidt, Jan. 26, 1934, at El. 9,500 ft. Chichivac. Seven specimens taken also by K. P. Schmidt, Feb. 4-7, 1934 (Mandel Expedition).

#### *Schmidtulus parvior* n. sp.

Figs. 30, 31

Brown above, with narrow yellow annuli and a series of light spots along each side, the sides and venter paler; anal tergite dark brown, with a mottling of some light spots over basal portion; collum yellow, with borders dark, the anterior dark band angularly produced back at middle and the posterior border band correspondingly produced forward; the yellow area with a network of dark lines; head yellow above, with a network of dark lines, and also yellow below, with a dark band between eyes, this inclosing a yellow spot on each side adjacent to the eye and sending two diverging prongs down the face. Legs and antennae yellow.

Eyes very widely separated, subcircular in outline, the ocelli arranged in 5 longitudinal series; e.g., 1, 3, 5, 4, 3. Clypeal foveolae 3 + 3.

Collum with ends on a level with other tergites; the lateral margin oblique, the anterior corner farther produced than the posterior which is more widely rounded off.

Ordinary segments with a conspicuous encircling furrow which is marked with rather coarse punctae throughout. The usual series of longitudinal striae on sides and beneath of the metazonites, the striae fine.

Anal scutum a little exceeding the valves. Anal valves with mesal borders not compressed or elevated; smooth and shining. Anal scale with caudal margin forming a slight obtuse angle at middle, its sides concave.

In the male the coxae of legs 3 to 5 with conspicuous conical processes, the apex of these narrowly rounded. Legs in front of the seventh segment all crassate, especially those of pairs 3 to 5.

Gonopods as represented in figs. 30 and 31.

Number of segments, 38 in both male and female.

*Locality*.—GUATEMALA: Volcan Tajumulco. A male and a female taken by K. P. Schmidt on Feb. 21, 1934 (Mandel Expedition).

#### NARCEUS AMERICANUS (Beauvois)

*Julus americanus* Beauvois, 1805, Ins. recueil. Afr. Amer. Apteres, pl. 4, figs. 3a-3c. (As *Julus americanae borealis* on p. 155). *Julus marginatus* Wood (non Say), 1865, Proc. Amer. Phil. Soc. 11:181. *Spiroboles americanae-borealis* Bollman, 1893, Bull. U. S. Nat. Mus. no. 46:145.

*Localities*.—ARKANSAS: Rich Mt., Polk Co., female, Mar. 22, 1938, K. P. Schmidt coll.; Ben Lomond, Sevier Co., Apr. 16, 1941, one female, K. P. Schmidt coll. ILLINOIS: Willow Springs, one female taken by W. J. Gerhard, June 11, 1922; Kaufman, Madison Co., a female, K. P. Schmidt coll.; Apr. 13, 1926; Bosky Dell, near Carbondale, Sept. 27, 1909, a female, W. J. Gerhard coll. INDIANA: Pikeville, Sept. 3, 1909, one male, G. T. Hildebrand coll. MICHIGAN: Leland, Leelanau Co., Aug. 3, 1932, one female, E. N. Peters coll. MISSOURI: Stone Co., Notch, Aug.-Sept., 1924, two specimens. NEW YORK: Catskill Mts., north of Samsonville, Aug., 1939, a female, Mrs. G. T. Hildebrand coll.

#### NARCEUS GORDANUS (Chamberlin)

*Spiroboles gordanus* Chamberlin, 1943, Bull. Univ. Utah, Biol. Ser. 8(2):9.

*Locality*.—FLORIDA: Charlotte Co., Punta Gorda, one male (the holotype) taken by Ramstad in Feb., 1940.

#### NARCEUS MELANIOR (Chamberlin)

*Spiroboles melanior* Chamberlin, 1943, Bull. Univ. Utah, Biol. Ser. 8(2):9.

*Locality*.—TEXAS: Stephen E. Austin State Park, 5 mi. E. of Scalesy. One female (the holotype) taken by K. P. Schmidt in April, 1941.

## NARCEUS ANNULARIS (Rafinesque)

*Rhexenor annularis* Rafinesque, 1820, Annals of Nature, p. 8. *Arctobolus onandaga* Cook, 1904, Harriman Alaska Expedition 8:64.

*Locality*.—ILLINOIS: Willow Springs. One female, E. B. Choche coll., Sept. 14, 1906.

## NARCEUS OROPHILUS (Chamberlin)

*Spirobolus orophilus* Chamberlin, 1943, Bull. Univ. Utah, Biol. Ser. 8(2):8, figs. 17-21.

*Locality*.—TENNESSEE: Sevier Co., Gatlinburg and Greenbriar Cove. Several specimens of both sexes, including types of the species.

## NARCEUS SPINIGERUS (Wood)

*Julus marginatus* Say, 1821, Journ. Acad. Sci. Philadelphia 2:15 (nom. preocc.). *Spirobolus spinigerus* Wood, 1864, Proc. Acad. Nat. Sci. Philadelphia, p. 15. *Spirobolus paludis* Chamberlin, 1918, Ann. Ent. Soc. Amer. 9:374.

*Localities*.—GEORGIA: Thomasville, Apr. 2, 1938, a female, Dr. H. Field coll., and June 9, 1842, a female, Mrs. E. Ireland coll. FLORIDA: Ormond Beach, Mar. 26, 1934, one female, Ed Brundage Jr. coll.

## On Five New North American Millipeds and Records of Some Established Species

Nell B. Causey  
Fayetteville, Arkansas

Holotypes of the species described in this paper are in the collection of the American Museum of Natural History. Paratypes have been retained by the author.

I wish to thank the collectors who have contributed material. In the case of records for which no collectors are mentioned, collection was by the author with the assistance of Dr. David Causey.

Family PARAIULIDAE  
Genus ETHOIULUS Chamberlin

1940, Bull. Univ. Utah 30:(11):9.

### *Ethoiulus unilictus* n. sp.

Figs. 1-4

Closely related to *E. amphelictus* (Chamberlin, 1918), but easily distinguished from that species by the fact that the accessory blade of the posterior gonopods of the male is simple rather than bifid.

*Male holotype*.—Dorsum brown; head, venter, and base of legs light brown; antennae and distal half of legs dark brown; dark brown band between eyes. Collum roughly quadrate, lateral margins with one entire sulcus. Ventro-cephalic angle of outer tooth of mandibles produced cephalad as is usual in the anilius group of the family. Eyes sub-triangular, 8 rows of ocelli, 11 to 5 in each row, the dorsal row amber colored and the others black. Sternite of eighth segment produced forward in a sharp keel (Fig. 1) which covers the base of the posterior gonopods. Anal spine sharp, curved slightly ventrad, extending as far beyond the anal valves as the setae on the valves.

Femoral lobe of anterior gonopods clavate, apparently thicker than in *amphelictus*; with the usual setae. Coxal lobe elongate, with 4 longitudinal ridges, widest beyond the middle of its length, then decreasing to a blunt end; it curves caudad to about the middle of the eighth segment, then ventrad, and finally cephalad, almost making a semicircle (Fig. 2).

Each posterior gonopod consists of an elongate seminal blade and a shorter accessory blade (Figs. 2, 4). The seminal blade curves cephalad, then ventrad, and finally dorsad, with the end coming to rest between the coxal lobes of the anterior gonopods. The two seminal blades are contiguous medially near the ends; the ends turn slightly laterad. The accessory blade, which arises on the lateral surface of the posterior gonopod, is simple, twisted about 90°, and slightly curved.

Width 2.6 mm., 57 segments.

*Locality*.—Ruston, Lincoln Parish, Louisiana. Collected in April, 1951, by Walter J. Harmon.

Genus OKLIULUS Causey

1950, Proc. Ark. Acad. Sci. 3:46.

### *Okliulus beveli* n. sp.

Figs. 5-7

A large species resembling *O. carpenteri* Causey, the only other known member of the genus, but distinguished from that species by the fact that the accessory blade of the posterior gonopods of the male is simple rather than bifid.

*Male holotype*.—Color in preservative brown above, buff below as high as horizontal striae; antennae and a band between eyes dark brown. Lateral margins of collum with one complete sulcus and two incomplete ones below it. First legs thicker than in *carpenteri*. Ventro-caudal angle of outer tooth of mandibles slightly produced; ventro-cephalic

angle as in *aniulus* group. Eyes subtriangular, 9 rows of ocelli, 11 to 3 in each row. Sternite of eighth segment not produced forward medially; anterior margin darkly pigmented medially; laterally it is produced ventrad enough to be slightly visible from a lateral view (Fig. 5). Anal spine sharp, curved slightly ventrad, extending well beyond anal valves.

Each anterior gonopod consists of a coxal lobe and shield and a clavate, setose femoral lobe (Fig. 6). The coxal shield is contiguous with its mate medially, the two covering the anterior half of the gonopodal opening. The coxal lobe, perpendicular to the main body axis, with the apex almost reaching the midline, is roughly triangular; there is a vertical ridge along its lateral margin and a horizontal ridge across its caudal surface.

Each posterior gonopod consists of two parts, the first a wide, flat seminal blade passing ventrad and then slightly cephalad, and the second a slightly longer, simple, weakly sinuate, narrow accessory blade arising from the lateral surface of the base of the seminal blade (Fig. 7). The seminal blades are contiguous.

Length about 42 mm., width 3.1 mm., 56 segments.

*Locality*.—Junction City, Union Co., Arkansas. Collected Oct. 11, 1950, by the Rev. H. M. Bevel, for whom it is a pleasure to name the species.

#### OKLIULUS CARPENTERI Causey

1950, Proc. Ark. Acad. Sci. 3:46, figs. 9-12.

*Records*.—ARKANSAS: Greenwood, Sebastian Co., Sept. 25 and Oct. 30, 1950; Camp Chaffee, Sebastian Co., Oct. 22, 1950; all collected by Ruth Steuart.

#### Genus ALIULUS Causey

1950, Proc. Ark. Acad. Sci. 3:45.

The male gonopods of the two species of this genus can be separated by the use of the following key:

- A. Pointed anterior division of end of coxal lobe of anterior gonopods small and horizontal; coxal lobes usually extend caudad of end of seminal blades; accessory blade of posterior gonopods usually not long enough to reach the acute bend at the end of the seminal blade ..... *carrollus*
- AA. Pointed anterior division of end of coxal lobe of anterior gonopods larger, sharply bent ventrad; coxal lobes narrower than in *carrollus*, the seminal blades always extending caudad of them; accessory blade of posterior gonopods closely appressed to seminal blade and long enough to reach the acute bend at the end of the seminal blade ..... *caddoensis*

#### ALIULUS CARROLLUS Causey

1950, Proc. Ark. Acad. Sci. 3:45, figs. 1-4.

*Records*.—ARKANSAS: Pindall, Searcy Co., Aug. 24, 1950; Gateway, Benton Co., Sept. 20, 1950.

#### ALIULUS CADDOENSIS Causey

1950, Proc. Ark. Acad. Sci. 3:46, figs. 5, 6.

*Records*.—ARKANSAS: Carthage, Dallas Co., Oct. 8, 1950, Billy C. Rogers; Greenwood, Sebastian Co., Oct. 18 and 30, 1950, Ruth Steuart; Rich Mt., Polk Co., Sept. 7, 1950; Dierks, Howard Co., Sept. 7, 1950; Delight and Antoine, Pike Co., Sept. 8, 1950.

#### Genus HAKIULUS Chamberlin

1940, Bull. Univ. Utah 30:(11):10.

#### HAKIULUS DIVERSIFRONS (Wood)

*Iulus* sp. Wood, 1864, Proc. Acad. Nat. Sci. Phila. p. 10 (Illinois); Wood, 1865, Trans. Amer. Philos. Soc. p. 197, fig. 30 (Illinois). *Iulus diversifrons* Wood, 1867, Proc. Acad. Nat. Sci. Phila. p. 43 ("South Illinois, rare in Western States, but very plenty in Texas"). *Hakiulus parallelus* Chamberlin, 1940, Bull. Univ. Utah 30(11):12, figs. 41-43 (Cleveland Co., Oklahoma; Fort Collins, Colorado).

There is little doubt that Wood's description of *diversifrons* was based on his single specimen from Illinois. In a recent comparison of specimens from Saybrook, McLean

Co., Illinois, and from Yukon, Canadian Co., Oklahoma, the male gonopods and outer tooth pieces of the mandibles showed no significant differences except that these structures were larger in the Oklahoma specimens than in those from Illinois. The greatest body width of Illinois and Arkansas specimens is about 3.1 mm.; in Illinois specimens it is about 2.6 mm. Since we know so little about the factors that determine body size in millipeds, this difference in size does not justify at this time the maintenance of *parallelus* as a distinct species from *diversifrons*.

*Records*.—ARKANSAS: Greenwood, Sebastian Co., Sept. 25, 1950, Ruth Steuart; Clarksville, Johnston Co., Oct. 15, 1950, Ruth Steuart; Washington Co., S. N. Elson.

Genus *TAIULUS* Chamberlin

1938, Proc. Biol. Soc. Wash. 51:205.

*Taiulus olympus* n. sp.

Figs. 8-10

Near *T. tiganus* (Chamberlin, 1910) but distinguished from that species by the details of the male gonopods, especially the bilobed and contiguous ends of the seminal blades and the broader ends of the coxal processes. Distinguished from *T. furcifer* (Harger, 1872) by the broadened and bilobed ends of the seminal blades.

*Male holotype*.—Dark yellow brown in preservative, venter and legs lighter. Lateral margins of collum straight, marginal sulcus divided and one entire sulcus above it. Outer tooth of mandibles greater in dorso-ventral diameter, the ventro-cephalic and caudal angles prolonged ventrad. Eyes subtriangular, 7 rows of ocelli, 10 to 3 in each row. Anal spine longer than in *tiganus*, slightly surpassing anal valves.

Coxal lobes of anterior gonopods moderately wide distally as in *furcifer*, not narrowed as in *tiganus* and ends not conspicuously bent ventrad; ventral surface smooth, slightly concave distally; dorsal surface excavated as shown in figure 8, with a lateral fold closely embracing the seminal blade of the posterior gonopods. From about midway of the length of the mesial surface of the seminal blade of each posterior gonopod, there arise two spinous processes (Fig. 10); the inner of these spines is the stouter and longer, reaching almost to the end of the blade after curving dorsad and laterad; the outer spine is shorter, smaller, and almost straight. Distally the seminal blade is bilobed, with the distal half of the mesial lobe finely hispid. *In situ* the seminal blades reach almost to the end of the coxal lobes (Fig. 9), with the mesial lobes contiguous medially and easily visible. This is in contrast to *tiganus*, where the lobes are smaller, the seminal blades are not contiguous medially and are shorter than the coxal lobes. It differs from Harger's figure of *furcifer*, which shows the seminal blade as spinous, with only one process, and without a hispid region distally.

Width 2.7 mm., 50 segments, the last 3 legless.

*Female allotype*.—Width 3.2 mm., 52 segments, the last 2 legless. Eyes composed of 7 rows of ocelli, 11 to 4 in each row. Vulvae closely appressed medially and larger than in *tiganus*. Sternite of second segment flares widely; sternite of third segment not excised to receive second legs as in *tiganus*.

*Locality*.—Olympic Hot Springs, Washington. Types collected by M. H. Hatch Aug. 24, 1941.

Genus *UROBLANIULUS* Attems

*Uroblaniulus* Attems. Chamberlin and Hoffman, 1950, Nat. Hist. Misc. no. 71:6.

Species of *Uroblaniulus* are known from both sides of the Rocky Mountains and from Canada south into Georgia. The species described here brings the number to 11, most of which are known from rather limited areas; several others undoubtedly remain to be discovered.

*Uroblaniulus caroliniensis* n. sp.

Figs. 11-12

A species near *U. atlantus* (Chamberlin, 1946), but distinguished by the details of the posterior gonopods of the male.

*Male holotype*.—Color in life unknown. Lateral margins of collum with two entire horizontal sulci. Eyes triangular, ocelli in 9 rows. Outer tooth of mandibles almost quadrate, the ventro-cephalic corner longest. Anal spine decurved as in *U. atlantus*.

Anterior gonopods closely resemble those of *U. atlantus*, but differ in the blunt ends and lateral protuberances of the femoral lobes. Femoral lobes setose along mesial surface and longer than coxal lobes; the latter are thickened and indistinctly striated along the mesial borders, which are excavated midway and almost touching distally. *In situ* the ventro-medial pieces of the posterior gonopods can be seen between the coxal lobes, and extending slightly beyond the latter are the ends of the plumes (Fig. 11). Each posterior gonopod consists of at least four pieces (Fig. 12): a simple ventro-medial piece with a tuft of setae near its base; a columnar piece ending in three small plumes; partly surrounding the columnar piece is an irregular sheath slightly longer than the ventro-medial piece, attenuated distally, and with two sharp lobes on the ventral margin; laterad is a simple, short attenuated piece. Dissection of fresher material might show another piece, since some members of the genus have a fifth piece.

Width 2.3 mm.

*Locality*.—Raleigh, North Carolina. Two males; one female, width 2.6 mm., genital apparatus undeveloped. Collected Nov. 8, 1937, by C. S. Brimley and D. L. Wray.

#### UROBLANIULUS CANADENSIS (Newport)

1844, Ann. and Mag. Nat. Hist. 13:247.

*Saülus jerseyi* Causey, 1950, Proc. Ark. Acad. Sci. 3:48, figs. 27-30.

*Records*.—NEW YORK: Ithaca, Cascadilla Creek, Oct. 1, 1950; Henderson Harbor, Jefferson Co., Sept. 3, 1950; all by R. E. Crabill, Jr.

#### UROBLANIULUS IMMACULATUS (Wood)

Causey, 1950, Proc. Ark. Acad. Sci. 3:49, figs. 31-36.

*Record*.—NEW YORK: Allegany State Park, Cattaraugus Co., Mar. 26, 1949, R. E. Crabill, Jr.

#### Family LYSIOPETALIDAE

##### Genus SPIROSTREPHON Brandt

Loomis, 1937, Proc. U. S. Nat. Mus. 84:(3006):105.

#### SPIROSTREPHON CREOLUM Chamberlin

1942, Bull. Univ. Utah 32:(8):9, figs. 24, 25.

*Records*.—ARKANSAS: Batesville, Independence Co., Aug. 24, 1950; Crowley's Ridge State Park, Greene Co., Aug. 23, 1950; Rich Mt., Polk Co., Sept. 6, 1950; Dierks, Howard Co., Sept. 7, 1950; Clifty, Madison Co., May 3, 1951. ILLINOIS: Danville, Apr. 22, 1933, J. Alsterlund; Joliet, V. Shelford; Effingham, May 8, 1949, G. Ulrich and A. White; Urbana, Mar. 21, 1937, M. D. Farrar; Pound's Hollow, Sept. 19, 1947, P. W. Smith.

#### SPIROSTREPHON LACTARIUM (Say)

Loomis, 1937, Proc. U. S. Nat. Mus. 84:(3006):108, fig. 16, 1, m. Chamberlin, 1942, Bull. Univ. Utah 32(8), figs. 26, 27.

*Records*.—INDIANA: Upland, Apr. 26, 1948, C. J. Bushey. NEW JERSEY: Rockaway, Morris Co., Oct. 1949, J. K. Dankel.

#### SPIROSTREPHON TEXENSIS Loomis

1937, Proc. U. S. Nat. Mus. 84(3006):109, fig. 16, n.

*Spirostrephon texense* Loomis. Chamberlin, 1942, Bull. Univ. Utah 32(8):9, fig. 28.

*Records*.—ARKANSAS: Fayetteville, Washington Co.; Carthage, Dallas Co., Oct. 8, 1950, Billy C. Rogers; Ponca, Newton Co., Aug. 25, 1950; Pine Bluff, Jefferson Co., May 12, 1951, C. Nichol; Carrollton, Carroll Co., Aug. 21, 1950; Harrison, Boone Co., Aug. 21, 1950. LOUISIANA: Ruston, Lincoln Parish, Apr., 1950, Walter Harmon. MISSISSIPPI: Piney Woods, Rankin Co., Apr. 24, 1950, Singleton Bender.

#### Family CAMBALIDAE

##### Genus CAMBALA Gray

Loomis, 1938, Proc. U. S. Nat. Mus. 86(3043):36.

## CAMBALA CRISTULA Loomis

1938, Proc. U. S. Nat. Mus. 86(3043):39, fig. 12.

Record.—NORTH CAROLINA: Highlands, Macon Co., Black Rock Mt., a pair from the hollow stem of a large mushroom, July 6, 1940, W. De Turk.

**Cambala cara** n. sp.

Figs. 13-14

A small species distinguished from others of the genus by the presence of lobes on only the first legs of males and by the details of the gonopods, of which the anterior resemble those of *C. annulata* (Say) and the posterior *C. ochra* Chamberlin 1943.

*Male holotype*.—Color in life gray with bright orange areas around the repugnatorial pores, soon becoming uniformly brown in alcohol. Postmentum relatively longer than in *C. cristula* Loomis. Head with six ocelli in a single series on each side. Lateral margins of collum straight and with a shallow sulcus. Collum and anal segment smooth and without crests; second segment with faint traces of crests only on pleura; third and fourth segments with weakly developed crests on dorsum and pleura; fifth through ultimate segments with crests well developed, four on the dorsum between the repugnatorial pores, and 11 or 12 below each pore; poriferous keels triangular. Surface of keels and crests smooth; prozonites finely punctate and longitudinally striate. Apex of anal segment short, the anal valves visible from above. First legs as in *C. cristula*; no other pregenital legs with lobes.

Gonopods as shown in figures 13 and 14. Lateral branches of anterior pair distally emarginate as in *C. cristula*, and the mesial branches closely appressed as in *C. annulata*, but with the flagella visible between them. The flagella, which are about four times the length of the mesial branches, are coiled in the large ovoid vesicle at the dorsal surface of the anterior gonopods. The posterior gonopods are distinguished by a bundle of several hamate setae subterminally arranged on the flattened and rolled posterior branch and by the distinctly bifid anterior branch; dorsally there is also an ovoid vesicle.

Length about 30 mm., width 1.6 mm., 56 segments.

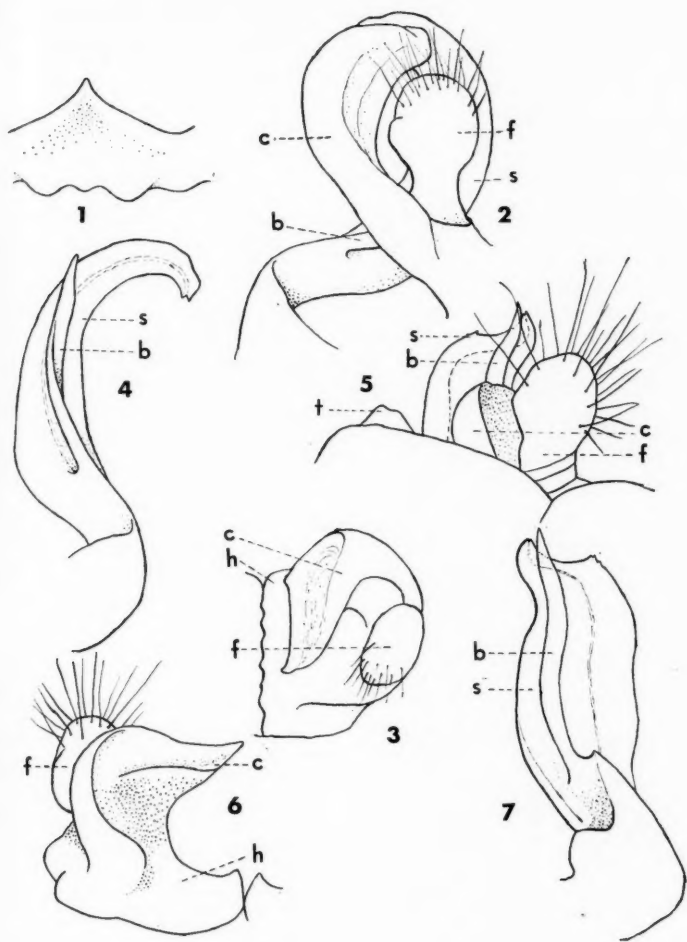
*Type locality*.—ARKANSAS: Benton Co., Cave Springs; 4 mature males and several females and larvae collected May 6, 1951, from under a piece of driftwood on a marshy creek bank by B. L. Tatum and A. H. Hulsey.

*Female allotype*.—Similar in color, size, and sculpturing.

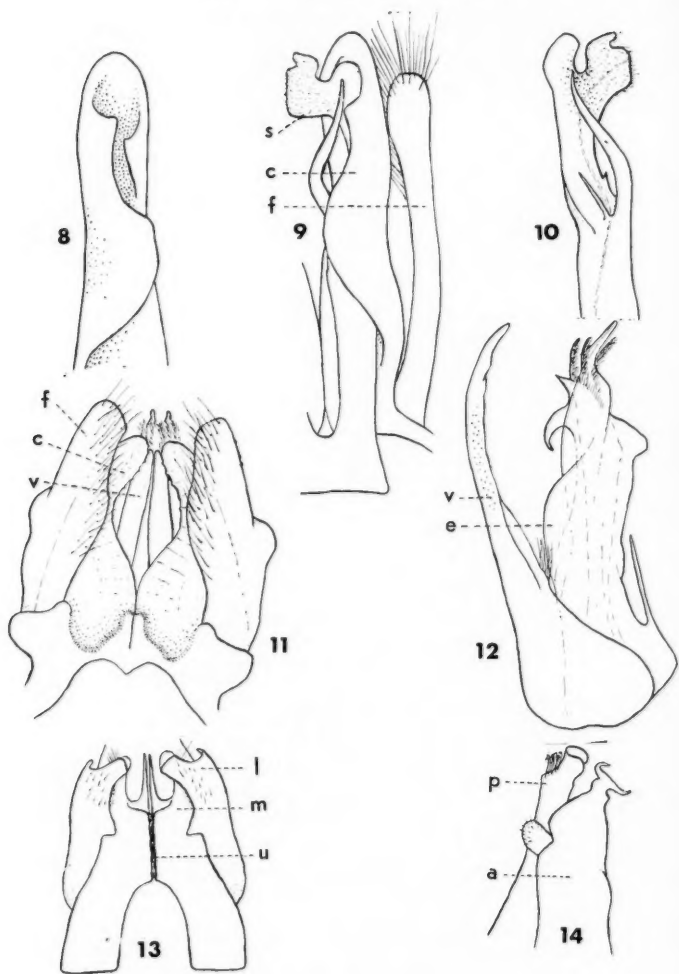
*Other localities*.—ARKANSAS: Washington Co.; collections of larvae and females believed to be this species have been made on a rather dry, oak covered hillside, on a less dry, oak-hickory covered hillside, and from Fincher's cave. Columbia Co.; numerous specimens, almost all females and larvae, were taken in pine forests near creeks in December of 1949 and 1950. LOUISIANA: Ruston, Lincoln Parish; 2 males and a female were collected by Walter J. Harmon in April, 1951.

*Relationships*.—Bollman's inadequate description of *C. minor*, originally reported from Indiana and Arkansas, has made identification of that species difficult. When the posterior gonopods of a specimen of *C. minor* from Bloomington, Ind., were examined recently, they were found to be similar to those of *cara*, but specific differences were found. Unfortunately the anterior gonopods of the Indiana specimen could not be examined; until it is possible to study more Indiana specimens carefully, it seems wise to present the Arkansas and Louisiana specimens described here as a new species, *cara*.





Figs. 1-7.—1-4. *Ethoiulus unilictus*. 1. Sternite of eighth segment, ventral view; 2. Left gonopods *in situ*, lateral view; 3. Right anterior gonopod, ventral view; 4. Right posterior gonopod, lateral view. 5-7. *Okliulus beveli*. 5. Left gonopods *in situ*, lateral view; 6. Right anterior gonopod, caudal view; 7. Right posterior gonopod, lateral view. Drawn from male holotypes to same scale. a—anterior branch, b—accessory blade, c—coxal lobe, e—sheath, f—femoral lobe, h—coxal shield, l—lateral branch, m—mesial branch, p—posterior branch, s—seminal blade, t—sternite, u—flagellum, v—ventro-medial piece.



Figs. 8-14.—8-10. *Taulus olympus*. 8. Right anterior gonopod, dorsal view of distal region of coxal lobe; 9. Left gonopods, dorsal view; 10. Seminal blade of right posterior gonopod, dorsal view of distal region. 11-12. *Uroblaniulus carolinienis*. 11. Gonopods in situ, ventral view; 12. Left posterior gonopod, mesial view. 13-14. *Cambala cara*. 13. Anterior gonopods, anterior view; 14. Left posterior gonopod, lateral view. Drawn from male holotypes to same scale except 13 which is about 1/5 larger, and 14, 15 which are about 1/2 larger. See figs. 1-7 for abbreviations.

# Notes on the Spawning Population of the Freshwater Drum (*Aplodinotus grunniens* Rafinesque) in Western Lake Erie<sup>1</sup>

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Although various aspects of the life history of the freshwater drum or sheepshead, *Aplodinotus grunniens* have engaged the attention of fisheries biologists, our knowledge of the subject is still incomplete. Van Oosten (1937) Schoffman (1941), and Butler and Smith (1950) have studied growth; Forbes (1880, 1888), Dendy (1946) and Daiber (1951), food habits; Dendy (1946), depth distribution; and Fish (1932), the description of the early young. Aside from Butler and Smith's discussion of age at sexual maturity (1950), we have no information on the spawning population.

In the course of a study of the freshwater drum in western Lake Erie during 1948 and 1949, a number of facts were gathered that contribute to our knowledge of the age at sexual maturity, seasonal changes in the gonads, egg production, limits of the spawning season, and of the presence of sub-groups in the spawning population. These observations provide the basis for this paper.

I wish to express my appreciation to the staff and students of Franz Theodore Stone Institute of Hydrobiology, especially to Dr. T. H. Langlois who made this work possible and to Drs. W. Spoor, J. Verduin and M. Trautman for reading the manuscript. Thanks are also due Dr. J. Freund of Alfred University for his assistance with the statistical analysis.

## METHODS

In order to determine the age at which the sheepshead matures, 111 males and 117 females were examined from the 1948 spring collections. The fish were aged by the scale method and the criterion for determining maturity was used as indicated below.

The immature gonads are pinkish in color and have a translucent appearance. When the females attain sexual maturity, the color of the ovaries changes to some shade of yellow. This change begins when only a few eggs are supplied with yolk material, giving the ovaries a speckled appearance. The testes change to some shade of brown, becoming lighter in color as they ripen.

The ratio of the ovary weight to body weight was ascertained by following the method described by Schloemer (1947), the ovary weight x 1000 being divided by the total body weight. Egg counts were made by the volumetric method, counting the eggs from a measured section taken from the center of one ovary and then computing the total number for both ovaries. Only those eggs were counted that were fully yolked and readily freed from

<sup>1</sup> Taken in part from a dissertation submitted in partial fulfillment for the degree of Doctor of Philosophy, Ohio State University, 1950.

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the general ovarian tissue. Egg size was determined by means of an ocular micrometer, 25 eggs from each size group being measured. For the histological examination of the ovarian tissue, the ovaries from four fishes caught at different times of the year were fixed in 10% formalin, and selected sections from the center of an ovary from each fish were prepared with Delafield's iron haematoxylin-eosin stain.

The material for demonstrating the presence of sub-groups in the spawning population was obtained on August 3 and 10, 1948, by means of an otter trawl towed over the bottom in the open lake. There were 583 and 368 individual young-of-the-year sheepshead used for the two respective dates. The possibility of sub-groups was suggested by Harding (1949), and the statistical analysis of multi-modal curves, i.e., departures from the normal by skewness and kurtosis, was derived from Rietz (1924, pp. 92-99) and Snedecor (1946, pp. 174-177), and the number of sub-groups was determined by the method described by Freund (see Lit. Cit.)

TABLE 1.—The percentage of mature males and females in various age groups.

Males			Females			
Age	Immature	Mature	Age	Immature	Partial	Mature
III	24 (100%)		IV	30 (100%)		
IV	27 (73%)	10 (27%)	V	16 (57%)	8 (29%)	4 (14%)
V	5 (21%)	19 (79%)	VI	4 (16%)	10 (38%)	12 (46%)
VI	1 (4%)	25 (96%)	VII		1 (8%)	12 (92%)
			VIII		1 (5%)	19 (95%)

## RESULTS

*Sexual maturity.* Table 1 shows the percentage of sexually mature fish in the different age groups. The males are designated as being either mature or immature while the females are separated into three classes: (1) immature, (2) partially mature, having ovaries partially filled with yolked eggs, or (3) mature, having ovaries entirely filled with yolked eggs. This procedure is followed because it is not known whether these partially mature fish will spawn. The percentage of each category is indicated in parentheses. It is apparent that males mature a year earlier than the females; the first males maturing during their fifth, and the first females maturing during their sixth growing season. Some males, however, remained immature until their seventh growing season and partially mature females as old as eight years were found. These observations differ from the data of Butler and Smith (1950) who found the males in the Mississippi River beginning to mature during their third season and females maturing during their fifth. They point out that the first fishes to become sexually mature were significantly larger than the average for their year-class. Such is the case with the female sheepshead in Lake Erie, where all the females examined in their sixth growing season averaged 281 mm Standard Length (13.8 inches TL), the fully mature females averaged 307 mm SL (15.0 inches TL), the partially mature, 287 mm (14.1 inches TL), and the immatures 270 mm (13.4 inches TL). The males

did not show such a variation during their fifth growing season; the mature males averaging 242 mm (11.9 inches TL) and the immatures, 239 mm.

There is a deceleration in the rate of growth when the sheephead reaches maturity. When the average lengths for each year class are plotted on semilog paper the change occurs at the sixth year for the females. This corresponds to the results in Table 1, in which there is a shift from 57% immature females in the fifth year to 16% in the sixth. The change for the males occurs before that of the females but it is not as distinct. This is partly explained by the fact that there appears to be no difference in the size of the males at the time they begin to mature.

*Seasonal gonad development.* Prior to the onset of seasonal growth there is a significant positive correlation between the gonad weight and total body weight. These relationships were set up using 35 females and 41 males from the April 27, 1948 collection, irrespective of the degree of sexual maturity. The following values were obtained; for the females  $R = 0.84$  and  $F(.01) = 7.47$  (33 d.f.), for the males  $R = 0.77$  and  $F(.01) = 7.33$  (39 d.f.).

With the approach of the spawning season there is a change in the gonad weight-body weight relationship, i.e., the gonads grow at a faster rate than the total body weight. Fig. 1 presents the ovarian development for the sheephead. The data include those females whose ovaries had yolked eggs, whether they made up the major portion of the ovarian mass or simply gave the ovary a speckled appearance. The ratio of ovary weight to total body weight reached a peak during the third and fourth weeks of June. Subsequent to the end of July, with the exception of the September collections, there is a levelling-off period with a gradual increase during the month of November. It is uncertain whether any significance can be attached to the rise in the ratios during early September. Mature females were not caught in 1949 after the period indicated. The males follow the same pattern as

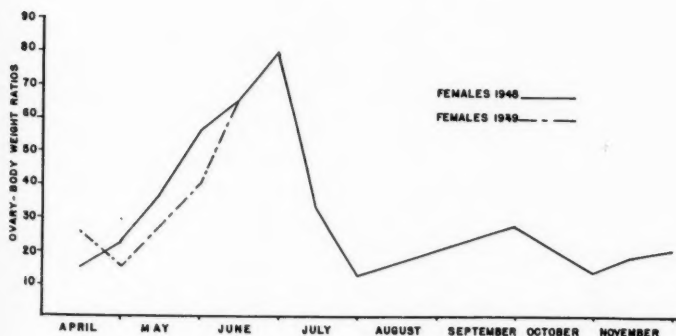


Fig. 1.—Ovary weight-body weight (gms) ratios  $\times 10^3$  for female sheephead during 1948 and 1949.

the females, although the peak is not as well defined and is spread over a greater period of time and with a lower intensity.

TABLE 2.—The numbers of eggs, ovary weight-body weight ratios, ovary weights and body weights of nine females from the 1948 collections.

Date	Age	Number of eggs	Ovary wt.-body wt. ratio	Ovary weight (gms)	Body weight (gms)
May 10	VI	317000	39.3	59	1503
May 10	VIII	341000	48.2	86	1786
May 10	VIII	209000	31.6	41	1297
May 10	VIII	508000	73.3	121	1651
May 26	VIII	290000	69.4	121	1744
May 26	VIII	213000	63.9	87	1361
Jun. 3	VII	224000	115.2	142	1233
Jun. 11	VII	225000	90.8	130	1432
Jul. 2	V	43000	34.7	36	1063

The spawning season is a prolonged one, but does have a peak period. Males with running milt were taken on June 8, 1949; the females collected at that time were not ripe. One spent female was collected on September 11, 1948. According to Schloemer (1947) the spawning period is indicated by the decline in the ovary weight-body weight ratio. On the basis of the 1948 collections of female sheepshead, the major portion of the spawning took place during the month of July. This is indicated by the drop in the ratio from 80.0 during the second half of June to 12.8 through the latter part of July, and is supported by the fact that the first collection of young sheepshead, consisting of fishes ranging in size from 11 to 16 mm SL was taken from the open lake on July 21, 1948.

*Number and size of eggs produced.* The egg counts for nine individuals are recorded in Table 2 along with dates of capture, ages, body and ovary weights and ovary weight-body weight ratios. The greater number of these fishes have between two and four hundred thousand eggs. There appears to be a relationship between the numbers of eggs, and age, in so far as those fishes just attaining sexual maturity are concerned. This may be true for the very old females as well.

TABLE 3.—Egg sizes in the ovary of a 5-year-old sheepshead caught August 3, 1948.

	Large-yolked (mm)	Median-yolked (mm)	Non-yolked (mm)
Average size .....	0.72	0.28	0.07
Size range .....	0.54-0.84	0.18-0.40	0.02-0.10

Associated with the spring increase of the ovary weight-body weight ratio, there is a corresponding increase in egg diameters. This is illustrated by the following data: the average diameter of yolked eggs from fishes caught on

April 7, 1948, was 0.46 mm; for the April 27 collection it was 0.58 mm. The largest size was attained in June with 1.02 and 1.03 mm for the two individuals measured.

Cross-sections of ovarian tissue were prepared from females caught at various times of the year in order to show the changes that take place within the ovaries. Fig. 2a shows the ovary of a five-year-old immature fish taken on May 17, 1949. The ovaries were pink in color, and contained no yolked eggs. One egg size is apparent with an average of 0.08 mm and a range of 0.04 to 0.10 mm. These eggs took the haemotoxylin stain and the cytoplasm of the cells was dense. Fig. 2b shows the three egg sizes found in the ovary of a mature five-year-old fish (sixth season) which was taken on August 3, 1948. The average sizes and size ranges are given in table 3. Eggs of the

TABLE 4.—Length frequency distribution of the August 3, 1948 collection of the young-of-the-year sheepshead.

1*	2	3	4	1	2	3	4
8-9	1.36	1		28-29	66.75	46	6.45
10-11	3.45	12.6	1	30-31	50.60	56	0.86
12-13	7.79	5		32-33	33.96	25	2.36
14-15	15.58	19	0.75	34-35	20.20	10	5.15
16-17	27.59	35	1.99	36-37	10.64	12	0.66
18-19	43.29	29	4.71	38-39	4.96	4	
20-21	60.16	40	6.76	40-41	2.05	8	3
22-23	74.06	60	2.67	42-43	0.75	1	0.13
24-25	80.77	77	0.18	44-45	0.24	1	
26-27	78.01	69	1.04				
				35.25 (11 d. f.)			

\* Column 1, interval in millimeters; 2, normal curve frequency; 3, actual frequency; 4, chi-square.

smallest size took the haemotoxylin stain and the cytoplasm of the cells was dense, while eggs of the largest size took the eosin stain and the yolk material was granular in appearance. Eggs of the intermediate size group are intermediate in stain reaction and appearance of the cytoplasm. Fig. 2c shows the spent ovary of a fish caught on August 3, 1948. Two size groups of eggs are present, the larger with an average of 0.22 mm and a size range of 0.14-0.30 mm and the smaller group with an average size of 0.07 mm and a size range of 0.02-0.10 mm. Fig. 2d shows an ovarian section of a fish caught on September 20, 1948, some time after spawning, when the ovarian tissue had recovered from the spent condition. The two egg-groups have an average size of 0.22 and 0.07 mm respectively, with corresponding size ranges of 0.16-0.28 and 0.04-0.10 mm. The spongy appearance of the section from the spent ovary is the main difference between the ovaries shown in figs 2c and 2d. This spongy material represents the areas from which the eggs were released during spawning.

*Spawning habitat and egg development.* The spawning act was not observed and there is no conclusive evidence as to the specific location where spawning occurs. There are but two possible habitats, the bays and lower river sections, and the open lake, and evidence points to both.



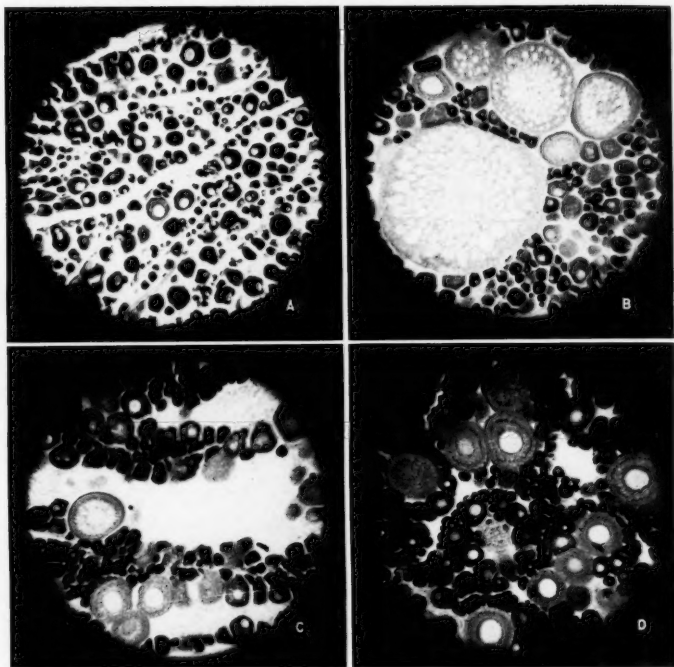


Fig. 2.—Histological changes in sheephead ovaries before and after spawning. a, Immature ovary. b, Mature ovary just before spawning, 3 egg sizes, largest egg 0.92 mm diameter. c, Spent ovary, 3 spongy areas denoting sites from which mature eggs had been released, 2 egg sizes. d, mature ovary some time after spawning, 2 egg sizes.

A number of small sheephead were taken from Sandusky Bay while seining during the summers of 1947 through 1949. The commercial fishermen reported large runs of sheephead into the bay prior to our taking the young fishes, and they also reported seeing large numbers of young fishes later in the season. This evidence suggests that the species spawns in water up to six feet in depth and over a bottom of sand and mud. In contrast, many collections of young-of-the-year sheephead were made with the trawl in the deeper waters of the open lake about the Bass Islands. It is possible that these young fishes were swept in by currents, but it does not seem probable that this would be the case for all of them. It seems more likely that the adult fishes spawned in the open lake, but whether they spawned close to shore or at some distance from the islands is unknown. The marine sciaenids show a variation in spawning grounds, either in the bays or the open ocean, depending on the species (Welsh and Breder, 1923, Pearson, 1928, Hildebrand and Cable, 1930).

No information is available to indicate whether the fishes spawn on the bottom or change their usual habits and forsake this region for the pelagic habitat during the spawning act. Budd (1940) indicates that fishes with pelagic eggs usually produce large numbers of small and spherical eggs. Development is rapid; hatching takes place at a very immature stage and the

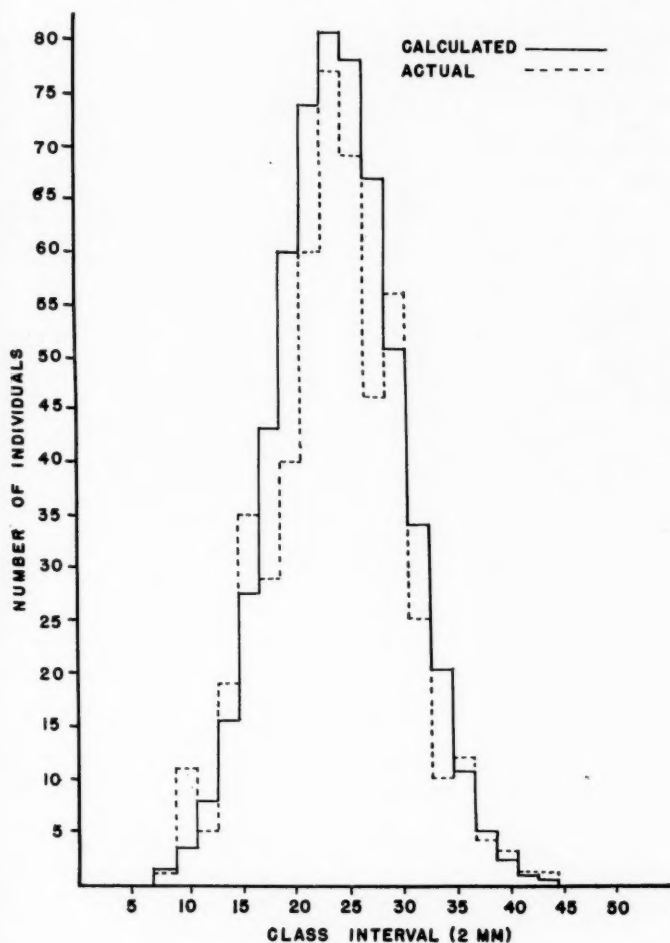


Fig. 3.—Actual and calculated length-frequency distribution of the August 3, 1948 collection of the young-of-the-year sheephead.

young fishes are helpless on account of the buoyancy of the yolk. The marine sciaenids produce small pelagic eggs (Welsh and Breder, 1923), and the data discussed under size and numbers of eggs suggest that the sheepshead has a pelagic egg. This supposition is supported by observations made by Harold Wascko of the Toledo Aquarium (personal conversation with the author), who has found eggs floating in the tanks with the sheepshead. He has observed that the fishes spawned at night, that it takes two days for the eggs to hatch and that the larvae float head downward.

*Sub-groups within the spawning population.* There are several sub-groups of adults within the spawning population. This is indicated by the fact that ripe or spent females are collected over a prolonged period of time yet each female spawns but once each season.

According to the statistics skewness ( $\alpha_3$ ) and kurtosis ( $\alpha_4$ )<sup>3</sup> there is a

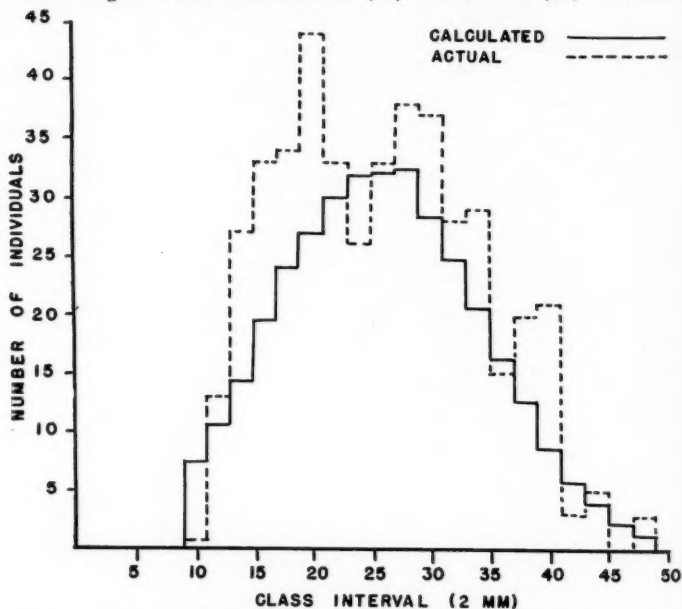


Fig. 4.—Actual and calculated length-frequency distribution of the August 10, 1948 collection of the young-of-the-year sheepshead.

<sup>3</sup> There are two major ways in which distributions may depart from the normal, i.e., by skewness and kurtosis. In a normal distribution, skewness will be absent so that the standardized moment about the mean,  $\alpha_3 = 0$ . Kurtosis is a measure of peaked-ness of the distribution, and, in a normal distribution, kurtosis measured by  $\alpha_4$  will equal 3. Deviations from  $\alpha_3 = 0$  will indicate an asymmetrical curve, and deviations from  $\alpha_4 = 3$  will indicate an excess of items near the mean and far from it in the case of a positive value of kurtosis, while a negative value is the result of a plateau-like distribution curve.

significant value for kurtosis ( $t(.05) = 2.13$ ) for the August 3, 1948 collection of the young-of-the-year sheephead. This indicates the possibility of a multi-modal curve or that there may be more than one population of young sheephead included in this particular collection. Both skewness ( $t(.05) = 3.08$ ) and kurtosis ( $t(.05) = 4.01$ ) are significant for the August 10, 1948 collection. This indicates that there is more than one population of young fishes in this collection.

A comparison of the normal curve frequencies and actual frequencies for the two collections is made in tables 4 and 5, and figs. 3 and 4. The observed and calculated frequencies for both collections were significantly different on the basis of a chi-square test. Since both kurtosis and chi-square indicate the presence of several populations of young sheephead, there must be several sub-groups among the spawning adults, even though each female spawns but once each season. (See section on number and size of eggs produced.)

Skewness of the distribution, kurtosis and chi-square do not indicate the number of populations of young sheephead in the two collections. A significance test of multimodality has been devised (Freund, see Lit. Cit.) and is used to determine whether the peaks of figs. 3 and 4 are the modes of the various sub-groups of the spawning population.

TABLE 5.—Length frequency distribution of the August 10, 1948 collection of the young-of-the-year sheephead.

1*	2	3	4	1	2	3	4
9	12.60	20.1		30-31	28.32	37	2.67
10-11	7.51		1	32-33	24.72	28	0.41
12-13	10.67		13	34-35	20.56	29	3.42
14-15	14.44		27	36-37	16.30	15	0.10
16-17	19.57		33	38-39	12.79	20	4.05
18-19	24.01		34	40-41	8.72	21	17.38
20-21	26.94		44	42-43	5.97	3	1.50
22-23	30.00		33	44-45	3.90	5	
24-25	31.82		26	46-47	2.42	9.4	0
26-27	32.17		33	48-49	1.43	3	0.20
28-29	32.36		38	50-51	1.60		

85.96 (15 d.f.)

\* Same as in Table 4.

Turning to the August 3 collection, there are five modes indicated in the frequency distribution of fig. 3 and table 4; at the intervals 10-11, 16-17, 24-25, 30-31, and 36-37 mm. Since the interval 24-25 mm represents the mode of the entire distribution and because the technique employed is designed for testing the tails of the distribution, no test will be made on this particular class interval; however, its location suggests one population mode. The first three intervals are significant ( $u(.05) = 16, 22$  and  $41$ ) and this would indicate that there are four different populations of the young-of-the-year sheephead. The class interval 36-37 mm is not significant, but this lack of significance should not be the sole criterion for discarding this interval as the possible mode of another population. The indication of four spawnings, with

a possible fifth, does not set an upper limit on the number of spawnings but merely means that there are at least four.

Examination of the August 10 collection in fig. 4 and table 5 reveals the possibility of three modes, one at 20-21, 28-29, and 40-41 mm. The 28-29 mm interval represents the mode of the entire distribution and in as much as the technique is not designed for the center of the distribution the test probably will not satisfy the necessary requirements. Only the last interval (40-41 mm) is significant ( $v(.05) = 23$ ). At first glance this would indicate only one population mode other than the one at the center of the distribution. However, if there are four populations of the young-of-the-year sheepshead with the possibility of a fifth in the August 3 collection, one may assume that these same populations should be present in a sample taken one week later. In this case a mathematical treatment fails to show any significance when it would be normally expected by a biological analysis.

#### DISCUSSION

Temperature as a physical factor in the environment apparently plays a major role in the life of the sheepshead. It influences growth rate, which in turn modifies attainment of sexual maturity. Temperature directly or indirectly determines the spawning season. This temperature factor becomes evident when we compare the growth rates of the sheepshead in the Mississippi River (Butler and Smith, 1950) with those in Lake Erie (Van Oosten, 1937). The differences can be explained by the fact that the waters of the former are warmer than those of Lake Erie. This is indicated by the northward bulge of the isotherms along the Mississippi River Valley.

Inasmuch as the fishes from the Mississippi River grow faster, sexual maturity is reached earlier, as evidenced by the fact that the females begin to mature during the fifth year with an average length of 15.2 inches (T.L.), whereas the females from Lake Erie begin to mature during the sixth year with an average length of 15 inches. The males from the Mississippi River begin to mature during the third year at 12.2 inches while those from Lake Erie begin to mature during the fifth year at 11.9 inches. In both cases each sex matures at about the same size, despite the difference in ages. There is no apparent reason why the males from the Mississippi River mature two years before those from Lake Erie.

As Butler and Smith point out, and as is demonstrated in the section on sexual maturity, those fishes that first reach maturity are longer than the average for that year class. This is true for both sexes from the Mississippi River but true only for the females from Lake Erie. The data at hand do not furnish an explanation for the fact that there is no apparent difference for the males from Lake Erie. It is uncertain whether these early maturing fishes will produce more viable eggs with the inherent possibility for greater survival. As brought out in the section on seasonal development of the gonads, the gonads increase in weight as does the total body weight. On the basis of a single V-year class fish the eggs tend to be smaller and also fewer in number in the younger individuals. This suggests that the early maturing fishes have no significant advantages over the older ones.

Inasmuch as the sciaenids as a group are warm water fishes, temperature no doubt is important in the seasonal development of the gonads. The increase in gonad size for the sheepshead is slow in early spring and begins after the commencement of feeding. As the water warms up metabolic activity increases, more food is consumed, the growth rate increases and there is an increased rate of yolk deposition in the eggs, shown by the increase of the ovary weight-body weight ratios and the size of the individual eggs. When the growing season is longer, or when the water warms faster as in the Mississippi Valley the sex products will mature at a higher rate, and the spawning season will be earlier. This is borne out by the fact that the peak of the spawning season in the Mississippi River is in the first two weeks of June (Butler and Smith, 1950) while that of the Lake Erie fishes falls in July.

The interrelationships between gonad development and general metabolic activity is evident among some species. In general these relationships are more evident among the females than the males. Carbine (1943) found the numbers of eggs increased with the length of the northern pike, *Esox lucius*. However, in contrast, Brown and Kamp (1941) found little or no correlation between length, weight, condition or age and the numbers of eggs produced or the weight of the testes in the brown trout, *Salmo trutta*. Such a relationship does exist between gonad weight and body weight of the sheepshead and it is more evident among the females. Although there is insufficient evidence to confirm it, this relationship will probably tend to break down among the very old female sheepshead, i.e., the ovary weight will not keep pace with the total body weight.

The seasonal changes in the gonads of the sheepshead have been utilized as a criterion to determine when spawning starts and the length of the spawning season for each fish. Mathews (1938) utilized the periodic differences in the weight, and gross and microscopic appearance of the gonads as an index; the ovaries undergoing a much greater fluctuation than the testes. Schloemer (1947) used the ratio between ovary weight and body weight to determine the commencement of spawning.

In order to determine the length of the spawning season for a single fish, Hickling and Rutenberg (1936) demonstrated that when the spawning season is short those eggs destined to mature will be drawn from the general egg stock in a single group, whereas when the season is a prolonged one there will be no clear-cut difference between the mature eggs and the general stock. This distinction is apparently general in nature since Carbine (1943) found that all eggs to be spawned in one season form a single group in the northern pike, *Esox lucius* and Reighard (1905) demonstrated three egg sizes for the black bass, *Micropterus dolomieu*.

Although there is reason to believe that the spawning period of the species is prolonged the data presented here suggest that the period for any one individual sheepshead does not last very long. The presence of three egg sizes and the easy separation of the largest group from the rest of the tissue is, according to Hickling and Rutenberg's (1936) criterion, evidence of a short spawning period. The presence of sub-groups in the spawning population further suggests that individual spawnings are so short in duration that the different

groups cluster about detectable modes when one attempts to draw a normal curve for the collections of young fishes.

It is not clear why there are several sub-groups in the spawning population. There are no sudden drops in the water temperature that would cause temporary halts during the spawning season. The differences in water temperatures in various parts of the lake are not of such magnitude that growth rates should be affected. It is possible that each mode in the spawning population curve represents a year class. This is borne out to some extent by the fact that the spent females taken early in the spawning season tend to be larger than those taken toward the end of the season. This suggests that the older individuals are the early spawners, followed by the progressively younger fishes. The water currents may, in part, account for the sub-groups that appear in the collections of young fishes. The eggs or the very small hatchlings may be brought into the region about the islands by the currents that are known to exist in the area. If the currents do bring in these young fishes, it would mean that the sheepshead spawns at slightly different times in various parts of the lake. Until further evidence is obtained, it is believed the differences that exist in the collections of young sheepshead are the result of different year classes spawning at slightly different times.

#### SUMMARY

The following observations were made on the spawning population of the freshwater drum in western Lake Erie during the course of an investigation in 1948 and 1949.

The male sheepshead begin to mature at four years of age with an average length of 242 mm SL; the females at five years with an average length of 307 mm SL.

The drop in the ratio between gonad weight and total body weight serves as an indicator for commencement of the spawning season. Most of the spawning appears to take place during July although recently spent females have been obtained as late as September 11. A significant correlation was obtained between gonad weight and total body weight.

The majority of the females examined produced between two and four hundred thousand eggs. The egg size increased with the approach of the spawning season and just prior to it the average diameter was one millimeter.

Before spawning the adult females have three distinct egg sizes with very little overlap between groups. After spawning there are two size groups in the ovaries, serving as the supply for the next season and subsequent years.

The location of the different spawning areas were discussed. The eggs have many characteristics which suggest a pelagic spawning habit.

A statistical treatment of two 1948 collections of the young-of-the-year fishes reveals that these collections were made up of at least four different size groups and this is considered an indication that at least four distinct sub-groups of adults spawned in the open lake.



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## Effects of a C-47 Airplane Application of DDT on Fish-food Organisms in Two Pennsylvania Watersheds

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For the control of many defoliators of the forest, DDT dispersed as a spray from airplanes has proved highly effective. The trend has been toward the use of large, fast airplanes to dispense DDT for the control of devastating pests during a susceptible stage of their life cycle, which frequently is of short duration. In widespread spraying operations many streams and ponds become contaminated with insecticides. Although spraying with poisons may be justified on the basis of saving our forests, many people have become concerned regarding its possible detrimental effects to wildlife.

Aquatic species appear to be affected more by DDT sprayings than terrestrial animals. To the extent that this is true, it is likely the effects are greater on aquatics because of their intimate and continuous contact with the insecticide. Studies summarized by Surber (1948) have shown that DDT is toxic to fish, and that the damage is usually proportional to the dosage and is especially serious in shallow bodies of water. Forest entomologists at present are interested primarily in single aerial sprayings made at the rate of 1 pound of DDT per acre, since this dosage is effective against several important defoliators. Field studies made in 1945 and in subsequent years on the effects of this dosage on fish and fish-food organisms have been limited to small streams or to 1-mile sections of large streams in the East. Under these conditions fish losses have been negligible, but 70 to 90 percent of the fish-food organisms have been eliminated shortly after the spraying. Further study indicated rapid insect repopulation, and a year later some of the streams contained a variety and abundance as great as before the spraying (Hoffmann and Merkel, 1948).

The question arises as to whether similar results would be obtained when thousands of acres, including important streams and their tributaries, are sprayed in a short period of time. In Idaho, where widespread spraying with 1 pound of DDT per acre was undertaken for the control of the Douglas-fir tussock moth (*Homocampa pseudotsugata* McD.), most of the aquatic invertebrates were eliminated in heavily treated areas (Adams *et al.* 1949). A study of one stream showed that annelids were unaffected, and that some reestablishment of other invertebrates occurred about two months after the spraying. Some cottoids, mountain suckers and black bullheads were killed by DDT; whereas rainbow, eastern brook and cutthroat trout, speckled dace and redeyed shiners were apparently unharmed. Moreover, studies are needed to de-

<sup>1</sup> The writers are indebted to F. C. Craighead, J. M. Corliss, and K. A. Haines for correlating the spray-control program with this research study; to E. P. Merkel for invaluable field and laboratory assistance throughout the study; to M. Mohr and W. I. May for intermittent help during the field season of 1948; and to the Division of Forest Insect Investigations and the Division of Insecticide Investigations, of the Bureau of Entomology and Plant Quarantine, for DDT analyses.

termine, under varying conditions, the rate of repopulation of bottom organisms in sprayed areas and their relationship to fish growth and survival.

In 1948 the opportunity arose to obtain information on the effects of DDT on fish and fish-food organisms when this insecticide was applied aerially to 52,000 acres of woodland in Pennsylvania for control of the gypsy moth *Porthetria dispar* (L.). This study area was of sufficient magnitude to involve many of the operational problems inherent in a large control operation and necessarily included many diverse ecological habitats. The status of aquatic insects was studied rather intensively within the sprayed area and in comparable check streams, and over 94,000 bottom insects were examined individually. Population studies of stream insects were made before and at intervals after spraying so that a qualitative and quantitative estimate of the total effects might be available. The minor fish losses resulting from spraying several streams and lakes have been recorded by Hoffmann and Surber (1949).

Under natural conditions most cold-water streams appear to produce a sufficient quantity of food to support a sizeable trout population. The food-chain relationships are numerous, variable and complex. Microscopic algae and small crustaceans serve as food for invertebrates, which seek them from rocks or trap them by means of straining devices as they are carried downstream by the current. The herbivores that feed in this manner include may fly nymphs, caddis fly, midge, and black fly larvae, and snails. Associated with them are predacious enemies or carnivores, such as some of the stone fly, dragon fly, and damselfly naiads, and megalopteron larvae. Trout are dependent upon these insects for food. Aquatic insects may be available on the bottom of the stream, or in the current after they are dislodged, not only during the various transformation stages but as ovipositing adults. This food supply is augmented by terrestrial insects that fall into the water.

Much has been learned about the food of speckled, brown, and rainbow trout by examination of the stomach contents of various-sized fish caught at different times of the year. Clemens (1928) has summarized earlier literature on this subject which indicates that insects predominate as food, sometimes representing over 80 percent of the bulk in the alimentary canal. His own studies of speckled trout showed that insects (mostly midge larvae and nymphs of the may fly *Baetis*) constituted over 90 percent of the food items in fish up to 4 inches in length. Trout in the 6-to-10-inch class had fed extensively on surface insects and fish. The food habits of brown and rainbow trout are essentially the same, except perhaps that large brown trout take more food from the surface than do speckled or rainbow trout. Raney and Lachner (1942) found that the autumn food of 2-to-4-inch brown trout 16 days after being planted in small streams was 86 percent aquatic invertebrates, of which 93 percent was insects (primarily Ephemeroptera and Diptera). An intensive investigation of the feeding habits of larger (7 to 30 inches in length) common trout by Metzelaar (1929) showed a decrease of insects in the diet and a marked increase of crustacea and fish as the size of the trout increased, particularly the rainbows and browns. Nevertheless, aquatic insects comprised over 25 percent of the food of all age classes for each species of trout.

Muttkowski (1925) reports that stone flies are the most important food

of cutthroat trout, constituting about 90 percent of the diet, with may flies second and caddis flies third in importance. He concludes that fish, in general, are opportunists as far as their food is concerned, eating available animal food regardless of origin, but sometimes show a predilection for a certain kind of insect. Muttkowski (1929) believes that stream insects are also opportunists, eating whatever is available, and that they forage extensively. Another study (Hazzard and Madsen, 1933) shows that in the diet of small fingerling cutthroats most of the stream fauna are represented; however, as winter food, midges were most important and stone fly nymphs ranked second. They deduce that the food of the cutthroat is similar to that of other species of trout, and varies greatly with the environment. Thus, it has long been realized that the invertebrate bottom fauna supplies the bulk of the food taken by the fish population of a stream. This food supply changes a great deal both qualitatively and quantitatively, depending upon the chemical nature, temperature, type of bottom, width, depth, velocity, and cover of the stream, and on other environmental factors such as floods and drought.

Although much valuable information concerning the food habits of fish has been obtained by examination of stomach contents, this information could have been enhanced if accompanied by a measure of the kinds and relative numbers or volume of food organisms present on the bottom of the stream from which the fish were taken. Several workers (Pate 1934, Hess and Swartz 1941, Leonard 1942, and Allen 1942) have considered this interaction and find great variations between the kinds and relative numbers of food items actually eaten by fish and those represented in the stream. Accordingly, it has been suggested that food grades should not be determined on the basis of the total number of organisms found on the bottom but instead on an "availability factor" defined as "a measure of the relative extent to which an animal is eaten determined by the ratio between its percentage occurrence in the stomach contents of a sample of fish and its percentage occurrence in the samples of the bottom fauna taken at the same time and place." (Allen 1942).

It is clearly evident from the studies cited that both aquatic and terrestrial insects comprise a substantial portion of the food of trout. Good trout streams originate in and flow through forested areas which periodically are subject to the attacks of devastating insects. Even though an aerial application of DDT can effectively control these pests that cause vast economic losses, fishermen and wildlife enthusiasts will be concerned about the direct and indirect effects of spraying on aquatic life.

#### DESCRIPTION OF THE AREA

The area sprayed is about 11 miles southeast of Wilkes-Barre, Pa., and includes the eastern half of Bear Creek Township, all of Buck Township in Luzerne County, and most of Lehigh Township in Lackawanna County (fig. 1). Most of the area is forested and parts of it are rugged. The few people who live in the area have homes near the lakes or streams, especially along highways. Many visitors are attracted to this area each year, particularly those interested in fishing and hunting. The forest is classified as a red oak-black oak-white oak type. Diverse stages of forest growth are evident throughout the area as a result of continuous heavy cutting and fire. The pioneer species—gray birch, red maple, black cherry, spotted alder, and rhododendron—are

the most prevalent growth along the margins of the streams. Highways and certain private roads made it possible to study different sections of the larger streams and their tributaries with a minimum of foot travel.

Major emphasis was placed upon the bottom insects of Bear Creek and its tributaries, inasmuch as this creek crossed the study area from north to south and included approximately 12 miles of stream. As shown on the map (fig. 1), the upper part of the creek flows through two artificial lakes, Antler Lake (15 acres) and Bear Creek Lake (85 acres). Two of the main tributaries, Meadow Run and Shades Creek, originate near the center of the sprayed area and appeared to be of special importance from the viewpoint of repopulation studies. The upper reaches of Bear Creek and its major tributaries are narrow, sometimes only 3 or 4 feet wide during periods of low water. A number of pools and a few substantial riffle areas are downstream where the width is about 30 feet. In general, however, Bear Creek is narrow to where it empties into Bear Creek Lake. Immediately below Bear Creek Lake the stream is rather broad for 2 miles, beyond which it fluctuates in width from 20 to 70 feet before emptying into the Lehigh River. The water in Bear Creek is soft and brownish; the flow is about 8,000 gallons per minute (17.7 cubic feet per second). Preliminary bottom sampling indicated considerable variation in the



Fig. 1.—Map of area near Wilkes-Barre, Pa., sprayed with DDT in 1948. Date of spraying indicated in each block. Sampling stations shown by numbered black dots in sprayed and check areas.

numbers and species of bottom insects in riffle areas throughout the length of the stream. In order to have a suitable control with the same species present it was necessary to select two streams, a small one (Wright Creek) to match the upper part of Bear Creek and a larger stream (Trout Creek) which is more comparable to the lower part of this Creek.

Some study was devoted to Choke Creek in another watershed of the sprayed area. This creek is 2 miles southwest of Thornhurst, Pa., and is about 6 miles in length and about 20 to 25 feet in width. Some sections of the stream are rather open, whereas others are well canopied by the forest (fig. 2). The rubble and boulders throughout most of the stream bed are covered with either a heavy layer of algae or moss. Trout Creek, in which most of the rocks are covered with moss, matched Choke Creek closely and was used as a check stream.

Both Bear Creek and Choke Creek are permanent, cold-water streams, which are said to have sustained large trout populations years ago. More recently, however, the trout populations have dwindled, owing to deforestation, severe floods, and heavy fishing pressure. In the spring the streams flood their banks; whereas late in summer drought may reduce the water level so drastically that fish have difficulty passing over extensive riffle areas. The bottom in riffle areas is largely rubble with some gravel and sand, and most of the rubble is covered with either algae or mosses. The velocity of the streams ranges from 1.5 to 4 cubic feet per second in the main riffles.

It will be noted (fig. 1) that Bear Creek, Choke Creek, and minor creeks



Fig. 2.—Filter-paper station in a riffle area with a fish weir in the background, Choke Creek.

in the sprayed area all drain into the Lehigh River, as do also Trout Creek, Tobyhanna Creek, and tributaries outside the sprayed area. Since Tobyhanna Creek had a fauna similar to that of the Lehigh River, it was used as a check stream. Both are deep and have bottoms containing boulders and large rubble; hence, they are difficult to sample.

#### TREATMENT OF THE AREA

Highways separated the area to be sprayed into convenient work units. Colored windsocks fastened in the tops of trees at strategic points assisted the pilots in locating boundaries. The spray formula consisted of 1 pound of DDT, 1 pint of xylene, and 7 pints of kerosene per gallon, and this solution was dispersed at the rate of 1 gallon per acre.

As shown in figure 1, in general, the upper parts of the streams were sprayed before the lower sections; hence, the maximum effects of the poison might be expected to be near the mouths of the streams. The area around the lakes was sprayed by small airplanes to minimize contaminating the water with DDT. The remainder of the area was sprayed by a C-47 airplane equipped to disperse a load of 900 gallons in 10 minutes. Beginning on May 16, the C-47 was used whenever weather permitted. Wind and rain delayed operations until May 25, after which large acreages were sprayed almost daily until the area was covered completely. All spraying operations were completed on June 14.

Methods—The abundance of stream insects was determined by taking samples with a square-foot stream sampler (fig. 3) at stations on the larger streams in two watersheds on the sprayed area, and in check streams on watersheds outside the sprayed area. Three square-foot bottom samples were taken, in riffle areas only, at the 17 stations (numbered black dots in fig. 1) during each sampling period. Collections were taken at the stations before the spraying and at the following approximate intervals after the spraying: 3 days, 1 month (July), 2 months (August), 3 months (September), 4 months (October), 12 months (May), and 16 months (September). Aquatic invertebrates other than insects were present in unimportant numbers.

Specifications for the sampler are given by Surber (1937). For this study a fine (44 mesh) nylon netting was used for the bag. This type of net proved durable and did not retain much water after it was wrung by hand. The greatest difficulty encountered with the sampler was seating it properly in water where the bottom was made up of large rubble. More time was required for taking samples when the streams were high after freshets or low after a drought. Drift samples were taken by holding the sampler so that 8 inches of water flowed over the lower frame for 5 minutes. Ordinarily these samples were collected near the mouth of a stream at  $\frac{1}{2}$  or 1-hour intervals.

In the field each bottom sample was preserved in a pint fruit jar containing 80 percent ethyl alcohol. At the laboratory each sample was placed in a white-bottom enamel pan, water was added, and the insects were picked individually from the debris and preserved in a vial containing fresh 80 percent alcohol. Many of the insects floated to the surface; others were picked from the bottom of the pan. Samples containing an abundance of algae or moss required more time to pick than those free of plant materials. Muddy samples were diluted with water until they were clear enough to permit the operator to see the insects. The picking of insects from detritus was tedious,





Fig. 3.—Photograph taken at Station 6 showing a technique for holding the square-foot stream sampler with one hand while loosening bottom insects from the rubble with the other hand.

but with the aid of laboratory facilities specimens were more readily separated than could be done under field conditions. Subsequently the insects were identified by means of a binocular microscope and tabulated. Volumetric measurements were made according to the procedure outlined by Ball (1948).

#### DISTRIBUTION OF SPRAY

An ocular measure of spray droplets and the relative amount of spray deposit was obtained by noting the presence of oil films on glass plates and water holes. These examinations indicated that spray coverage was good. Wind was frequently an important aid in dispersing the spray to places that were covered with dense forest growth.

In order to obtain an estimate of the amount of DDT reaching the water, filter paper was fastened to plywood platforms nailed to 4-foot stakes. Eight of these stakes were distributed 100 feet apart in open sites either adjacent to or in the stream itself, at Stations 1 to 10 and at Stations 13 and 14 (fig. 2). Each filter paper was thumbtacked to the platform in such a way that an area of 1 square foot was exposed to the spray. The deposits on the filter paper analyzed chemically for DDT by the total-chlorine method, averaged 0.36 pound of DDT per acre, ranging from 0.06 to 1 pound. Stations 4 and 14 were sprayed twice and each received almost 0.6 pound of DDT per acre. Station 7 was covered twice, but analysis of filter papers indicated an average deposit of only 0.24 pound. This station did not appear to have more over-

hang than Station 14, but for some unknown reason only a small amount of DDT reached the water, as indicated by the filter paper deposits and by the small biological effect on the bottom fauna.

#### EFFECTS OF DDT ON STREAM INSECTS

*Immediate effects:* Prespray surface-drift samples taken at the mouth of Shades Creek yielded a maximum of 11 bottom insects moving downstream during a 5-minute collecting period. These specimens were early instars of *Baetis*, *Leuctra*, and the family Tendipedidae. The spraying of Shades Creek was begun at 8:20 a. m., and a drift sample collected at this time contained 6 bottom insects. Within half an hour the number of affected insects sextupled. The greatest number of affected bottom insects were caught after 2½ hours. This collection of 821 individuals included many *Baetis*, *Leuctra*, *Nemoura*, *Chloroperla*, *Isoperla*, *Hetereliminus* adults, *Hydropsyche*, *Rhyacophila*, and tendipedids.

Fifty nymphs each of *Iron* and *Isoperla* were removed from a drift sample and caged in contaminated water to investigate the possibility of their recovery from DDT tremors. Twenty-four hours later 90 percent of the *Iron* and 15 percent of the *Isoperla* nymphs had died. The remaining *Isoperla* had tremors. Twenty-five large *Ephemerella* nymphs similarly caged recovered from DDT tremors in 24 hours.

Most of the data on samples taken before and at intervals after spraying are shown in table 1. The Bear Creek samples are represented by stations 1 to 10 and the Choke Creek samples by stations 13 and 14. Stations 15, 16, and 17 served as checks.

Analyses of bottom samples collected at Stations 7 and 8, 2 and 4 days after the spraying showed a small quantitative loss at Station 7 but a large decrease in the population downstream at Station 8, which had received DDT-contaminated water on 4 consecutive days. Except for black fly larvae, which were eliminated, depopulation at Station 7 was slight. Conversely, population reduction was general at Station 8, with elimination of black flies, a severe loss of may flies and caddis flies, and a moderate loss of stone flies. It is interesting to note that the Shades Creek drift samples contained no black fly larvae, even though they were represented in prespray bottom samples. Examination of drift samples from other creeks in the sprayed area revealed only an occasional black fly larvae, whereas their eradication in these streams was shown by postspray bottom sampling.

Some *Nigronia* species were affected by DDT. Species of *Sialis* and *Corydalus* were resistant to DDT poisoning at the 1-pound-per-acre rate. Species of Odonata naiads also appeared to be resistant.

*Repopulation studies*—Square-foot bottom samples are the denominator for all repopulation studies reported herein (table 1). They represent the most convenient and satisfactory technique for surveying streams yet devised (Leonard 1940). When interpreting aquatic population data quantitatively, however, one should bear in mind that sometimes phenomenal differences in the distribution of bottom insects occur within a few feet of each other in the same riffle area (Mottley *et al.* 1939). Because of this important variable and others associated with it, it is desirable to present and interpret the data graphically

so that population trends may be observed for each watershed (figs. 4, 5, 6, and 7).

When plotted on graph paper, the Bear Creek watershed data, based on 30 samples each month, provided an easily fitted curve; whereas the Choke Creek data, based on 6 samples each month, resulted in a meandering curve which, nevertheless, approximates the trend of recovery indicated by the Bear Creek graphs (figs 4 and 5). The drought in the summer of 1949 had a severe effect on the stream-insect population at Choke Creek Station 14; consequently, the average population shown for this stream is low.

Figure 5 presents a clear picture of what happened after the spray was applied and, coupled with postspray drift data, may allay conjecture that the population decrease was due to seasonal variation. Stations 1 to 10 were treated between the middle of May and the first week of June 1948, and the minimum population level appeared in June, whereas Stations 13 and 14 were treated during the second week of June and the population was lowest in July. All the population minima for the check streams came in July. A noticeable quantitative reestablishment of bottom organisms was evident 2 or 3 months after the spraying.

Although the generic composition was changed and certain groups that were present in prespray samples had not returned by August 1948, it appeared evident that a gradual increase in bottom fauna was taking place. By this time an abundance of *Ephemerella* nymphs and midge larvae were present in the treated streams. Moderate numbers of black fly larvae were also present at several stations. By October large numbers of *Nemoura* were found in the bottom samples. Except for certain caddis flies, repopulation of all streams was complete by autumn.

A stream survey conducted in May 1949 revealed that the aquatic-insect populations in the streams of both sprayed watersheds had equaled or exceeded prespray numbers (fig. 5). The volume of insects per square foot, on the other hand, exceeded the prespray level for Choke Creek, whereas it was considerably lower for Bear Creek (fig. 4). Caddis flies, exclusive of *Rhyacophila* and some psychomyids, were exceedingly susceptible to DDT poisoning. They were not abundant in the treated streams a year after the spraying, but a subsequent survey in September revealed good numbers and a variety of caddis flies (table 1). For example, Station 6 had a prespray population of 70 *Hydropsyche* per square foot. After the application of DDT only an occasional one was found until September 1949, when the average was 85 specimens per square foot of bottom. Similarly, the small numbers of several caddis fly genera (table 1, other Trichoptera)—*Psilotreta*, *Lepidostoma*, *Ocetis*, *Trentonius*, *Neophylax*, and *Sericostoma*—appeared to be severely diminished after the spraying, but by September 1949 they were reestablished in the treated streams. Larvae of the genus *Chimarra*, however, have not been found at any of the treated stations since the spraying.

Certain factors cushion the effects of aerial applications of insecticides on aquatic fauna. The spray program within which these aquatic studies were made was singularly concerned with the eradication of the gypsy moth, a defoliating pest that can be controlled with aerially distributed DDT when the spraying is timed to coincide with early larval stages. In the aquatic habitats studied

TABLE 1.—Average numbers of stream-bottom insects per square foot at indicated sample stations in two watersheds in Pennsylvania before and after an aerial application of DDT at 1 pound per acre. Three 1-square-foot bottom samples averaged per station.

Insect groups	1 9 4 8												1 9 4 9											
	May*				June				September				May				September				September			
	Sprayed Sta. 1-10	Sprayed Sta. 11-12	Sprayed Sta. 13-14	Check 15-17	Sprayed Sta. 1-10	Sprayed Sta. 11-12	Sprayed Sta. 13-14	Check 15-17	Sprayed Sta. 1-10	Sprayed Sta. 11-12	Sprayed Sta. 13-14	Check 15-17	Sprayed Sta. 1-10	Sprayed Sta. 11-12	Sprayed Sta. 13-14	Check 15-17	Sprayed Sta. 1-10	Sprayed Sta. 11-12	Sprayed Sta. 13-14	Check 15-17	Sprayed Sta. 1-10	Sprayed Sta. 11-12	Sprayed Sta. 13-14	Check 15-17
<b>Ephemeroptera</b>																								
<i>Baetis</i>	4.0	2.2	0.4	23.6	0.2	0.8	0.0	7.8	0.7	0.8	0.0	43.1	0.5	0.4	0.0	33.2	7.6	15.8	9.7	45.7	95.6	30.5	83.8	24.9
<i>Ephemerella</i>	1.3	11.8	4.0	17.6	0.9	1.6	1.0	16.0	13.3	33.0	14.5	40.6	21.4	47.6	65.0	40.3	10.4	0.5	3.4	5.8	10.4	0.5	3.4	5.8
<i>Habrophlebia</i>	0.8	0.2	0.0	0.9	0.6	0.0	0.5	0.1	0.2	0.0	0.0	2.3	0.7	3.0	0.4	2.2	2.0	31.3	2.6	2.3	2.0	31.3	2.6	2.3
<i>Iron</i>	4.1	10.8	0.4	1.4	0.1	0.4	0.0	7.4	0.2	9.2	0.0	2.2	5.5	23.5	0.0	3.1	2.7	33.0	1.0	27.8	2.7	33.0	1.0	27.8
<i>Paraleptophlebia</i>	0.0	18.3	0.0	24.8	0.0	0.5	0.0	10.4	0.1	1.3	0.0	6.3	0.0	22.7	0.0	28.0	6.2	3.6	0.4	18.5	6.2	3.6	0.4	18.5
<i>Pseudocleon</i>	0.0	3.2	0.0	2.3	0.0	0.0	0.0	0.0	3.4	9.4	0.4	27.6	0.3	6.2	0.0	1.6	23.4	38.2	12.8	72.6	23.4	38.2	12.8	72.6
<i>Stenonema</i>	1.4	7.0	0.4	6.9	0.0	0.5	0.0	8.8	2.2	27.6	0.0	159.2	0.3	6.2	0.0	18.8	3.8	102.5	3.8	18.7	3.8	102.5	3.8	18.7
<b>Other Ephemeroptera</b>	0.0	4.0	0.0	0.0	0.0	4.0	0.2	0.4	0.0	8.3	0.0	13.1	0.0	0.4	0.4	0.1	5.0	5.2	4.4	10.8	5.0	5.2	4.4	10.8
<b>Odonata</b>																								
<i>Plecoptera</i>																								
<i>Acroneuria</i>	2.5	0.8	3.2	2.3	0.5	1.0	2.0	2.6	0.1	0.3	0.0	4.0	0.0	0.2	0.0	0.8	0.3	1.6	0.0	0.5	0.3	1.6	0.0	0.5
<i>Isoperla</i>	0.4	0.0	2.2	12.4	0.0	0.0	0.0	7.3	1.7	0.0	0.8	10.7	0.0	0.4	0.4	2.6	15.4	0.0	13.0	2.3	15.4	0.0	13.0	2.3
<i>Leuctra</i>	42.6	2.5	100.7	0.8	6.8	0.3	10.8	2.2	1.7	0.0	0.0	0.7	2.0	0.2	0.0	9.5	0.5	0.2	0.0	1.0	0.5	0.2	0.0	1.0
<i>Nesobittacus</i>	9.2	0.5	58.0	0.1	10.9	0.0	31.8	0.7	5.8	0.0	25.2	0.0	99.8	1.5	334.8	1.5	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0
<b>Other Plecoptera</b>	2.6	1.2	0.7	2.1	0.3	0.4	0.0	7.1	0.5	0.0	0.5	1.2	0.3	0.2	0.0	5.0	0.6	0.0	0.0	2.7	0.6	0.0	0.0	2.7
<b>Megaloptera</b>																								
<i>Corydalus</i>	0.0	0.4	0.0	0.0	0.0	0.7	0.0	0.1	0.4	2.6	0.4	0.4	0.0	0.5	0.0	0.4	0.4	0.8	0.0	0.7	0.4	0.8	0.0	0.7
<i>Nigronia</i>	2.7	0.0	1.8	0.5	1.1	0.0	0.5	1.0	3.2	0.4	0.4	2.4	1.7	0.0	0.5	2.8	6.0	0.0	2.5	1.7	6.0	0.0	2.5	1.7
<i>Stalis</i>	0.6	0.2	0.6	0.3	0.6	0.2	1.2	0.2	0.7	0.0	0.0	0.6	0.5	0.0	0.2	0.0	3.7	0.0	6.2	1.2	3.7	0.0	6.2	1.2
<b>Coleoptera</b>																								
<i>Heterelmis</i> adult	0.9	0.5	2.0	4.1	0.2	0.0	0.3	2.5	5.4	0.0	0.0	2.2	0.0	0.0	0.0	5.2	1.7	0.5	0.2	5.1	1.7	0.5	0.2	5.1
<i>Heterelmis</i> larva	4.0	0.0	24.3	5.3	3.9	0.6	8.6	20.0	0.6	0.8	0.0	58.2	0.3	0.0	0.0	56.5	9.8	0.2	0.2	79.0	9.8	0.2	0.2	79.0
<i>Stenelmis</i> larva	2.5	0.0	0.0	9.1	0.3	1.0	0.0	4.9	0.0	0.0	0.0	12.8	0.0	0.0	0.0	8.7	0.0	10.9	0.0	10.9	0.0	10.9	0.0	10.9
<b>Other Coleoptera</b>	0.7	1.0	0.0	2.3	0.5	1.4	0.7	4.1	0.6	1.7	0.0	4.3	0.4	0.5	0.2	1.6	9.4	21.6	0.8	55.8	9.4	21.6	0.8	55.8
<b>Trichoptera</b>																								
<i>Chimarra</i>	0.7	2.5	0.2	2.1	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	2.1
<i>Hydropsyche</i>	9.9	0.7	0.4	18.7	0.2	0.0	0.2	3.1	0.2	0.4	0.0	4.7	0.0	0.0	0.0	7.3	17.4	11.6	0.2	34.1	17.4	11.6	0.2	34.1
<i>Psychomyia</i>	1.1	1.8	0.8	0.8	0.1	0.4	0.2	2.2	0.2	0.4	0.0	5.8	0.1	0.0	0.0	8.8	3.0	0.7	0.7	9.1	3.0	0.7	0.7	9.1
<i>Rhyacophila</i>	2.4	0.4	1.5	1.3	0.5	0.3	0.2	2.2	2.4	0.4	0.0	3.8	0.4	0.0	0.0	1.5	2.1	0.8	0.2	3.2	2.1	0.8	0.2	3.2
<b>Other Trichoptera</b>	1.4	1.8	6.4	21.3	0.4	0.5	0.2	11.9	0.1	0.8	0.0	34.4	0.4	1.2	0.0	3.2	2.8	9.4	0.8	52.6	2.8	9.4	0.8	52.6
<b>Diptera</b>																								
<i>Simulidia</i> larva	103.8	0.8	6.8	52.6	0.0	0.0	0.0	1.3	5.1	0.0	0.0	161.2	5.0	0.4	0.2	5.3	26.6	3.2	0.5	5.9	26.6	3.2	0.5	5.9
<i>Simulidia</i> pupa	1.1	0.4	0.0	0.4	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.4	7.4	0.0	0.0	0.4	1.1	0.0	0.0	0.0	1.1	0.0	0.0	0.0
<i>Tendipedidae</i> larva	38.0	38.4	29.6	17.7	1.1	5.0	0.5	28.1	88.6	26.8	198.4	123.3	94.6	16.4	4.0	85.2	67.5	13.7	70.8	189.0	67.5	13.7	70.8	189.0
<i>Tendipedidae</i> pupa	1.2	2.0	0.7	1.7	0.3	0.8	1.6	1.2	3.0	0.6	4.6	12.6	3.6	1.2	1.2	3.9	4.2	1.8	4.4	8.4	4.2	1.8	4.4	8.4
<b>Other Diptera</b>	1.4	0.8	2.0	1.7	0.9	0.2	2.5	2.0	0.3	0.0	0.0	2.3	0.3	0.0	0.0	1.7	1.4	0.2	0.0	1.0	1.4	0.2	0.0	1.0
<b>Total</b>	242.1	114.6	248.8	235.7	32.2	23.8	64.2	174.5	143.1	129.1	247.3	747.2	245.6	129.0	407.5	340.5	335.2	328.2	226.4	529.6	335.2	328.2	226.4	529.6

\* Prespray.

there were seven orders of bottom insects comprising many species. This bottom life with its diverse habits, life cycles, and susceptibility to DDT poisoning, although sharply diminished for 1 to 2 months, was never eradicated at any of the sampling stations (table 2). By the third postspray month the trend toward qualitative and quantitative recovery was initiated generally. Two sources for regeneration of postspray populations are survivors, whether in the egg or another developmental stage, and immigrants.

The results of sampling at some stations showed their bottom fauna to be affected lightly (table 2). One of these, Station 7, is located in the heart of the sprayed area. From this nucleus, nearby creeks could be replenished with an aquatic fauna. Prespray surface-drift samples contained small numbers of immature insects, and adults were seen ovipositing every time the streams were revisited. Data given by Leonard (1942) emphasized the role of drifting bottom fauna in populating a newly excavated stream channel. Midges, *Leuctra*, and *Nemoura* were observed ovipositing prior to and during spraying operations. Bottom samples taken 2 and 3 months after treatment were rich in *Nemoura* and *Ephemerella* nymphs, as well as in midge larvae. The only important source of black flies and casebearing and net-spinning caddis flies was outside the sprayed area. Biological factors, such as species having short and overlapping life cycles (Moffet 1936), combined with physical factors that are always associated with the spraying of large forested tracts, mitigate the effects of temporary stream pollution.

Since it took about a month to spray the acreage under study, no simultaneous mass poisoning occurred. Intermittent adverse flying weather allowed

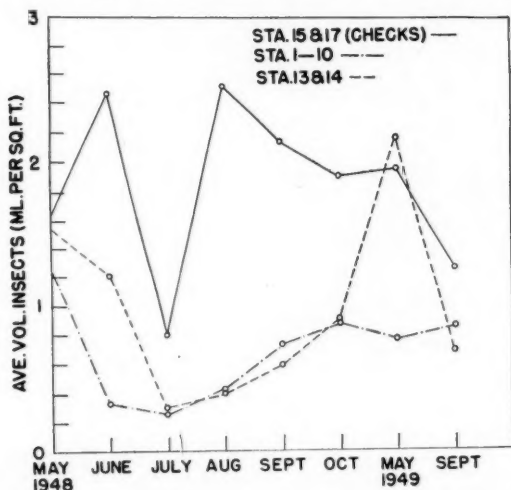


Fig. 4.—Average volume of bottom insects taken at stations in Wright Creek and Trout Creek (checks) and in Bear Creek and Choke Creek sprayed by airplane with 1 pound of DDT per acre.

a certain amount of natural recovery to take place. Other physical factors involved in the recovery of affected streams were the location of the headwaters outside the treated area (Bear Creek only) and the proximity of a network of untreated streams to the margins of the treated area (fig. 1). Probably occasional dense canopy also protected some small pools from the spray.

It appears then that there are a multiplicity of interrelated factors which prevent any but transient diminution of the aquatic fauna after the application of a 1-pound dosage of DDT to large forest areas.

*Residual and accumulative effects of DDT in streams*—Samples of moss collected 1 month after Choke Creek was sprayed at distances of about 1, 2, 3, and 6 miles from its head were analyzed chemically for DDT and found to contain 0, 44, 110, and 128 p.p.m., respectively. These amounts suggest that there was an accumulation of DDT from the head to the mouth of the stream. Another sample of moss collected 5 weeks after the spraying at the mouth of Choke Creek contained 48 p.p.m. of DDT. Samples of

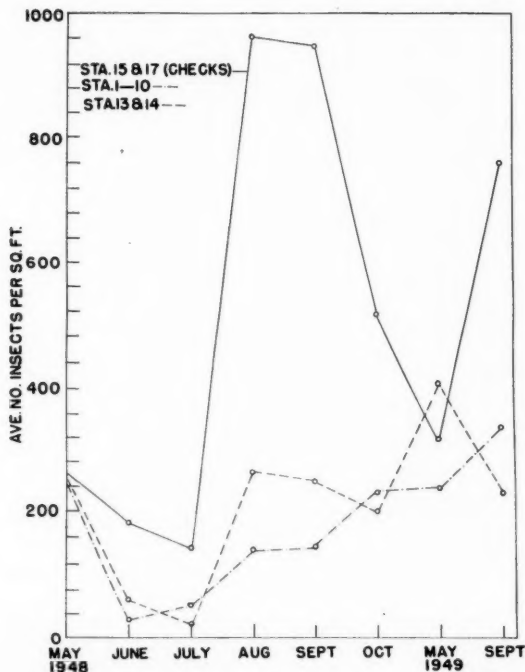


Fig. 5.—Average numbers of bottom insects taken at stations in Wright Creek and Trout Creek (checks) and in Bear Creek and Choke Creek sprayed by airplane with 1 pound of DDT per acre.

TABLE 2.—Over-all effect of DDT on bottom organisms on the basis of 3 square-foot samples taken 1 week before and 1, 4, and 8 weeks after the spraying at each station. Spraying completed on June 14, 1948.

Insect groups	Sprayed														Unsprayed		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
<b>Ephemeroptera</b>																	
<i>Baetis</i>	—*	—	—	—	—	—	x*	x	x	x	0*	0	—	—	—	0	0
<i>Ephemerella</i>	0	0	—	0	—	—	—	0	0	0	0	0	0	—	—	0	0
<i>Habrophlebia</i>	0	—	—	—	—	—	—	—	0	x	—	—	—	—	x	—	—
<i>Iron</i>	—	—	—	—	—	—	x	x	x	x	0	0	—	—	—	0	—
<i>Paraleptophlebia</i>	—	—	—	—	—	—	—	—	—	—	x	x	—	—	—	0	0
<i>Pseudocleon</i>	—	—	—	—	—	—	—	—	—	—	0	0	—	—	—	0	0
<i>Stenonema</i>	—	—	x	x	—	x	—	x	x	x	0	0	—	—	—	0	0
Other Ephemeroptera	—	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—
<b>Odonata</b>																	
<i>Plecoptera</i>	—	—	—	—	—	0	0	—	—	—	—	—	—	—	—	—	—
<i>Acronuria</i>	0	x	x	x	—	x	—	x	x	x	x	—	x	x	—	0	0
<i>Isoperla</i>	—	—	—	—	—	x	—	—	x	—	—	—	x	x	—	—	0
<i>Leuctra</i>	0	x	x	x	x	x	0	x	x	x	x	0	x	x	—	0	0
<i>Nemoura</i>	x	x	0	0	0	x	0	0	0	0	—	—	0	0	—	—	—
Other Plecoptera	—	—	—	—	—	0	x	x	x	x	—	x	0	—	—	—	0
<b>Megaloptera</b>																	
<i>Corydalus</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Nigronia</i>	0	0	0	0	0	0	0	0	0	—	—	—	0	x	—	0	—
<i>Statis</i>	—	—	0	—	—	—	—	—	—	—	—	—	0	—	—	—	—
<b>Coleoptera</b>																	
<i>Heterelmis</i> adult	—	—	0	0	—	0	—	—	—	—	0	—	x	—	—	0	0
<i>Heterelmis</i> larva	0	0	0	0	0	—	0	—	—	—	—	—	x	0	—	0	0
<i>Stenelmis</i> larva	x	—	x	—	—	x	—	x	0	x	—	—	—	—	0	0	0
Other Coleoptera	—	—	—	—	—	0	0	—	—	—	0	—	—	—	—	0	0
<b>Trichoptera</b>																	
<i>Chimarra</i>	—	—	x	—	x	x	—	—	—	—	x	x	—	—	0	x	0
<i>Hydropsyche</i>	x	x	x	—	x	x	x	x	—	x	—	—	—	—	0	0	0
<i>Psychomyidae</i>	—	—	x	0	—	x	x	x	x	—	—	x	x	—	—	0	—
<i>Rhyacophila</i>	—	0	x	0	0	0	0	x	—	—	—	—	x	x	0	—	—
Other Trichoptera	—	x	x	—	—	—	—	x	—	x	x	0	x	x	—	0	0
<b>Diptera</b>																	
<i>Simuliid</i> larva	x	x	x	x	x	x	x	x	x	x	x	—	x	x	x	0	0
<i>Simuliid</i> pupa	—	—	—	—	x	x	—	—	x	x	—	—	—	—	—	—	—
<i>Tendipedid</i> larva	0	0	0	0	0	0	0	0	0	0	0	x	0	0	0	0	0
<i>Tendipedid</i> pupa	0	—	0	0	0	0	—	—	0	0	0	0	—	0	0	—	0
<i>Tipulid</i> larva	0	x	x	—	0	—	0	x	—	—	—	x	0	—	0	0	0
Other Diptera	—	—	0	—	—	0	—	0	—	—	0	—	x	—	—	0	—
Percent of insect groups greatly reduced or eliminated	30	58	58	30	42	55	38	76	56	76	35	43	59	58	22	5	0

\* x denotes greatly reduced or eliminated; 0 denotes not greatly reduced; — denotes prespray population level less than 1 insect per square foot.

algae collected 18 and 24 days after the spraying yielded 25 and 23 p.p.m. of DDT. Evidently the DDT sank to the stream bottom, where it lodged in plant material. This deposit may partially account for the mortality of fish and fish-food organisms observed for a month after the sprayings. As previously reported by Hoffmann and Surber (1949), moss collected from rocks in Choke Creek 18 days after spraying contained enough DDT to be lethal to goldfish.

Bottom samples supplemented by drift samples indicate that from 70 to 90 percent of the bottom stream insects are eliminated within 3 days after the spraying. Bottom samples taken near the mouths of creeks or their tributaries showed greater losses, in general, than those taken at stations upstream.

Stations 11 and 12 were established to obtain a measure of harmful effects on bottom organisms in large rivers which receive the entire drainage of an



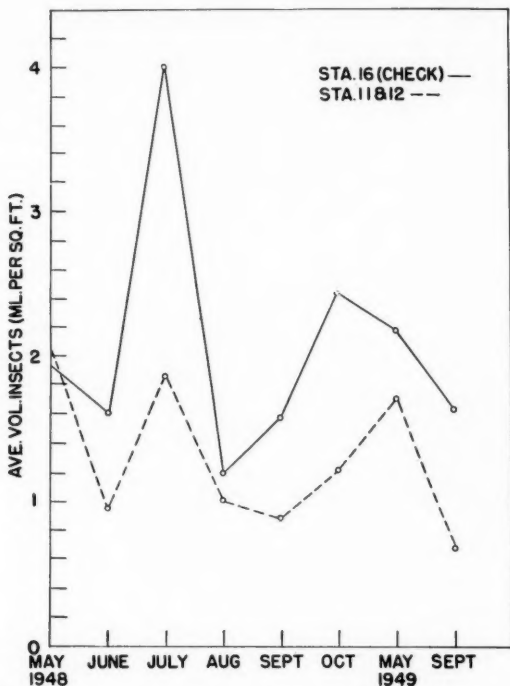


Fig. 6.—Average volume of bottom insects in Tobyhanna Creek (check) and in the Lehigh River which received the drainage of the 52,000-acre area in Pennsylvania sprayed by airplane with 1 pound of DDT per acre.

extensive area treated with DDT. The samples from both stations were similar in nature and therefore have been combined. Undoubtedly the total effects of the spray at these stations were greatly modified by the flow of untreated water from the headwaters of the Lehigh River. Under these conditions important but not devastating losses occurred at the lowest station, which was about one-half mile below the sprayed area (figs. 6-7).

*General effect of reduction in fish-food organisms on fish*—An exact appraisal of the effects of a sudden reduction in bottom food supply on the fish in a stream would necessitate a study not only of the fluctuations in bottom organisms but also of the stomach contents of fish in the same stream to note which insects were actually available and utilized for food during and after the spray operation. Other studies are needed to determine the effects, if any, of a sudden reduction in food supply on the growth of fish. As yet most DDT studies on fish have been concerned only with direct mortality. Other questions arise in the minds of those closely associated with

large control projects. Fish feed extensively upon insects, both aquatic and terrestrial, shortly after spray applications. Can fish that gorge upon DDT-affected bottom insects survive and remain in good condition without such food for a considerable period of time? Postspray bottom samples showed that numbers of aquatic insects survive sprayings at 1-pound dosages and may be available as food. This study was limited to insects inhabiting riffles, whereas some fish-food organisms exist in pools. Since pools are frequently deep and have mud bottoms, it is doubtful whether inhabitants such as species of tendipedids and Odonata are adversely affected by DDT, for little happened to them in riffle areas. Fish are able to forage and hence may be able to obtain sufficient food until the insect fauna of riffle areas is reestablished. Because the 1-pound-per-acre dosage, and even greater dosages, only momentarily reduces a considerable portion of the terrestrial insect fauna (Brues 1947; Hoffmann *et al.* 1949), certainly many of these species will fall into the water and serve as fish food. Nevertheless, the marked reduction in stream insects within a few days after the spraying cannot be minimized, for it represents a tremendous loss of potential fish food. It is hoped that a detailed study can be made by aquatic biologists to determine whether this reduction in food supply may be important in well-stocked streams. The rather rapid repopulation of insect species in waters sprayed with DDT, however, is remarkable. Hoffmann and Surber (1949) found that fish seined and ex-

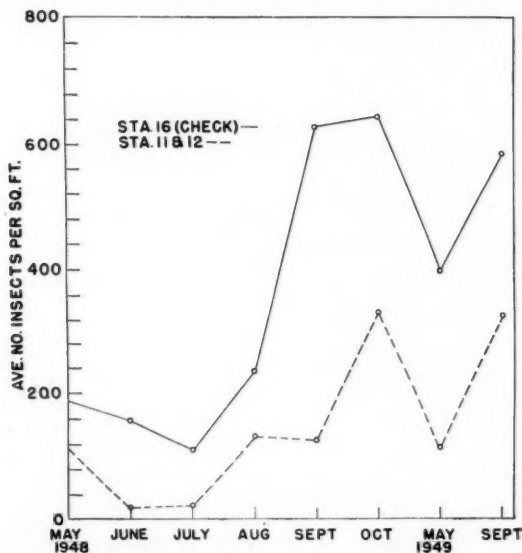


Fig. 7.—Average numbers of bottom insects taken in Tobyhanna Creek (check) and in the Lehigh River which received the drainage of the 52,000-acre area in Pennsylvania sprayed by airplane with 1 pound of DDT per acre.

aminated 2 months after the treatment were in good condition.)

In Idaho, after a 1-pound-per-acre application of DDT, crayfish were the only item that increased in the percentage composition of stomach contents of brook and rainbow trout removed from sprayed streams (Adams *et al.* 1949). Though crayfish populations of similar size occurred in untreated streams they were not eaten by trout in preference to other food. These workers also found that the volume of food in the stomachs of trout from DDT-treated streams was not significantly less than that from untreated streams, and that paralyzed crayfish made up for the decrease in other food items.

#### SUMMARY

An area comprising two watersheds totaling 52,000 acres near Wilkes-Barre, Pa., was sprayed aerially with 1 pound of DDT per acre during May and June 1948 to control the gypsy moth *Porthetria dispar* (L.). Research was conducted to investigate the effects this application would have on the stream-bottom insects that serve as food for fish.

The sprayed area, check area, treatment, study methods, and distribution of the spray are described briefly.

A prespray surface-drift sample contained 11 bottom insects of 3 genera. At the start of spray operations there were 6 insects of 5 genera in a sample, whereas  $\frac{1}{2}$ -hour later the number of affected insects has sextupled. The maximum number of affected insects were caught  $2\frac{1}{2}$  hours after the spraying and consisted of 821 individuals representing many genera.

Before and at designated intervals after the spraying the bottom fauna was sampled with a square-foot bottom sampler at 14 stations in the treated area and at 3 check stations. The samples were taken to corroborate drift sample data and to study repopulation.

The insecticide rapidly diminished the numbers and volume of bottom insects in the streams, but none of the 14 stations in the treated area were completely depopulated and losses at a few stations were small. Insects of the orders Megaloptera and Odonata appeared to be resistant to DDT poisoning at the dosage applied. Trichoptera were affected severely and were not taken in large numbers and variety until 16 months after the area was sprayed. In general, the trend toward repopulation was evident by August, 2 months after application of the DDT, and by autumn, except for certain caddis flies, the samples revealed ordinary numbers of bottom insects.

Certain biological and physical factors hinder the eradication of aquatic insects during large-scale spray operations. These factors include a great variety and abundance of aquatic insects having diverse life histories and habits, variation in susceptibility of species to DDT poisoning, ecological differences in streams, variation in tree canopy, proximity of untreated streams that furnish immigrants for repopulation, and influences of weather on the application and distribution of the insecticide.

Chemical analyses of moss, collected from Choke Creek 1 month after the spraying, contained 0, 44, 110, and 128 p.p.m. of DDT at distances of 1, 2, 3, and 6 miles, respectively, from its source. These data indicate that

DDT particles accumulate on stream plants in important amounts downstream, coinciding with the insect mortality which increased from the source to the mouth of the stream. It appears that some fish and insect mortality during the first postspray month resulted from this residue.

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## On Certain Small Terrestrial Mammals That Are Alleged to Fish with the Tail

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Animals do many strange and unusual things, particularly in hiding from their enemies and in seeking their food. These feeding habits are of great interest to the present writer, especially when land mammals (terrestrial feeders) depart so far from the normal habits of their associates as to seek fishes and other water-dwellers for their food.

When land mammals, that ordinarily do not go into the water for their food, go a-fishing with their tails, it becomes news. Then as a student of natural history and particularly of the uncommon things that fishes do and that are done to them, I become very much interested. And among the unusual things done to fishes and other water-dwellers is the alleged catching of them by the use of the tail by certain small land mammals. Over many years I have made and filed away occasional notes of such fishings and have now grouped them in this article since it seems time to bring the accounts of such fishings in chronological order under each animal fisherman, and to attempt an evaluation of the instances quoted.

### DO CERTAIN FELINES USE THE TAIL AS A LURE?

In 1946, I published an article in which the question was asked and tentatively answered for the alleged use of the tail as a lure in fishing by two felines, one wild and one tame. It seems well here, as an introduction to this article, briefly to recapitulate the evidence for each animal.

*Does the jaguar use its tail as a lure in fishing?*—The accounts of this fishing by the jaguar in central South America ranged from J. R. Rengger in 1830 to Dr. Paul Fejos (personal communication) in 1946. Among the men quoted were Alfred Russell Wallace (1853), W. L. Herndon (1853), Koch-Grunberg (1921) and Dr. Fejos (1946). The range in time is 116 years, and in space from the rivers of southern Brazil to the northwestern headwaters of the Amazon—in all, throughout the whole of Amazonia, over tens of thousands of square miles of territory. The authors had their accounts from Indians in whom they had confidence and from "reputable white settlers." A professional engineer (Linocurt) claimed that he had seen this fishing and so reported to Herndon, who published his statement. These men, in whose books the accounts are found, were explorers and naturalists of much experience in South America and were not easily deceived. Their recitals cannot be lightly thrown aside.

The jaguar, unlike most felines, likes water and is a good swimmer. He

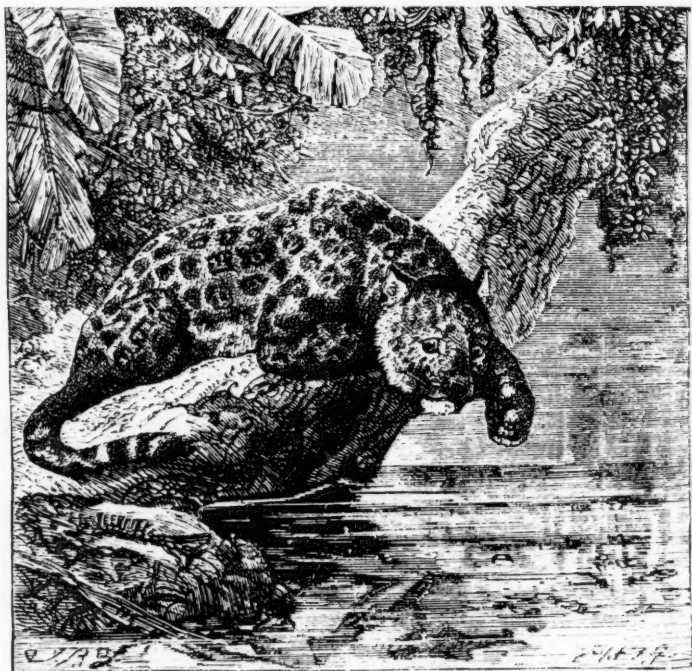


Fig. 1.—A jaguar, from the base of a tree leaning over a stream, hooks out the fishes swimming below. From *The Amazon and its Wonders*, 1881

is also a great fisherman and he normally gets his prey by frequenting the banks of streams abounding in fishes, which he hooks out with a paw.

However, his best fishing is done under certain fruit-bearing trees which grow on the banks of and overhang the streams. When their fruits ripen, they fall into the water and the "plops" attract certain characid fishes, which are fond of these fruits and which "hang around" under the trees watching for them. When these fruits fall, the fishes in crowds dash for them. The jaguar, from a rock or log projecting into the water (Fig. 1), scoops out one with a clawed paw. If he misses his prey once or twice, he is likely, in anger, to lash out with his tail—like a cat at a rat hole. When the tail taps the water, the fishes, thinking this disturbance means falling fruits, come up to—their fate. The jaguar, being an intelligent animal, soon learns that the tail-tapping brings his dinner and, it would seem, adopts this useful technique.

*Does the house cat use the tail for fishing?*—While this jaguar article was being written, I noted in one of my North Carolina papers a drawing of a house cat sitting on the rim of a goldfish pool with the tip of its tail in the

water (Fig. 2). The caption of the picture said that it was using its tail as a lure. After some correspondence, I got the address of the owner of the pool. He wrote that a neighbor's cat, when it came to the pool to drink, would often snatch out a fish which was attracted to the surface by the disturbance. When the fish did not come up, the cat, apparently in disappointment, would swing its tail about and would tap with it on the water. Then, when these inquisitive goldfish came up within reach, it would hook one out. This presently might become a habit. Every effort was made to verify this account, with the result that it seemed worthy of credence.

#### DO CERTAIN SMALL TERRESTRIAL MAMMALS FISH WITH THEIR TAILS?

With the above introduction, we now turn to the study of allegations of a different use of the tail in fishing by certain small mammals. These are all flesh-eaters and, indeed, fish-eaters. We will begin with the early accounts.

*Does the fox fish with his bushy tail?*—The fox is an omnivorous carnivore and is exceedingly fond of fishes and crayfishes. Likewise, he is one of the most keen-witted of wild animals. Hence, it is not surprising that he is alleged to have discovered a most ingenious way of obtaining his prey. But he certainly does not dive and catch the fishes and crayfishes as do the otter and the mink. However, he is accused of following these fishermen and eating the fish which they leave on the banks of streams or, at any rate, the

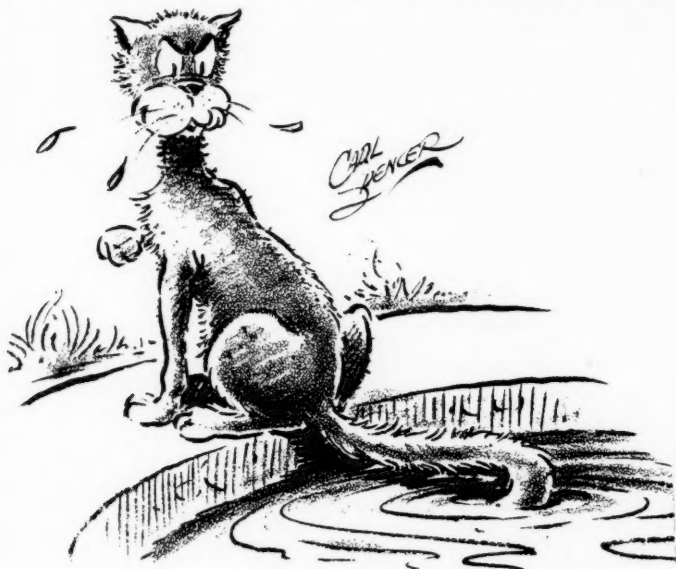


Fig. 2.—Drawing of a house cat tapping with its tail in a goldfish pool to attract its prey. By courtesy of the artist, Carl Spencer, 1942



fragments when the catchers have fed and gone on. The fox certainly does not dive and catch his own prey. However, he comes near to doing so.

Rodahl, the Greenland explorer (1946, p. 55), states that the Eskimos insist that the fox can fish from an advantageous position on the banks of a stream by splashing with a paw on the surface of the water to attract the fishes. With his paw, he then knocks them out onto the bank and devours them. However, it has long been alleged that the fox fishes with his hairy tail and it is with such fishing that we are particularly interested.

1. Folklore in the Southern U. S. A. Anticipatory of solid allegations to follow, there will now be introduced a bit of folklore from the southern parts of the U. S. A. This is the Negroes' story of how the fox catches fishes with his tail. I first heard it when a little boy in my southern home in the middle 1870's. It came from the lips of the antebellum Negroes—and from one man in particular. When Joel Chandler Harris was inspired to collect the "Brer Rabbit" and "Brer Fox" and other stories and publish them as the "Uncle Remus" stories, the joy of southern children knew no bounds.

In the story *Why Brer Rabbit Is Bob-tailed* we read that one day Brer Rabbit met Brer Fox coming down "de big road" with a large string of fishes. When asked how he got them, Brer Fox said that "atter sundown he would go to de creek and drap his bushy tail in de water and set there ontill daylight." Then he would come up out of the water with a lot of fishes sticking to the hairs of his tail.

Where and how the Negroes got this story is a mystery to the present writer. But an ethnologist of high standing tells me that it is agreed by the best authorities that the Negroes brought to the southern U. S. A. the essence of many of these adventures of the animals from West Africa, but, in the environment of the southern U. S. A., they left off their African animals and made use of those they knew in the southern fields and woods.

However, this homely bit of folklore is probably found in many countries and languages of Europe. At any rate, one must go to that small continent for the first written account of a fisherman fox.

2. The Fisherman Fox in Classical Times (120 A.D.). That this story of the fox as a tail-fisherman dates back to the remote past is evidenced by the fact that the present writer has found it in the writings of the old Roman, Claudius Aelianus (flourished ca. 120 A.D.). Of much interest to us is his *De Natura Animalium*. This work, written in the second century A.D., went through many early printings from 1533 to 1744. The American Museum library has the *editio princeps* of 1556, published at Zurich ["Tiguri"]. In *Liber VI*, Caput XXIII (p. 127), is seemingly the first published account of Reynard as a tail-fisherman. Here it is, as kindly translated by Professor Henry T. Rowell of the Johns Hopkins University:

Moving along the banks of streams, the fox cleverly catches little fishes. For he lets down his tail into the water and they swimming up to it are caught in the thick hairs. When the fox feels this, he quietly removes his tail from the water and stepping off suddenly to a dry place, he shakes his tail, and the little fishes fall off and are devoured by him.

Aelianus' book in manuscript saw the light of day in the second century of our era (ca. 120 A.D.). One wonders how long before this old Roman

wrote it down, the story of the fisherman fox was circulated by word of mouth in southern Europe. Aelianus sets the story down so casually that one gets the impression that it was a common happening of his day.

3. The Fisherman Fox in Sweden (1555). The next account, and, so far as this search shows, the second published account—and the first with a figure—is in a book by the famous Archbishop of Upsala, Sweden, Olaus Magnus. This book, *De Gentibus Septentrionalibus*, was published in Rome 1555.

His *Liber XVIII*, Caput XXXIX (p. 636) is entitled *De deloso ingenio Vulpium* (Concerning the crafty nature of foxes). In this short chapter of Olaus Magnus' book, there are five instances alleged of the cunning of the fox. The last of these reads thus (in Professor Rowell's translation):

As he roams the banks of streams, the fox sets a trap for crabs [Cancri—crayfishes?] and little fishes. He lets his tail down into the water and when they come up to it, attracted by its novelty, they become entangled in the hairs. They are then drawn out on land.

From this one must conclude that, in the Sweden of Olaus Magnus's time, foxes caught with their hairy tails fishes and crustaceans—the latter probably more often. Furthermore, the telling is without any special emphasis—as if the employment of the tail for fishing were a well known occurrence.

Fig. 3. is a reproduction of Olaus Magnus's old wood cut set at the head of his Caput XXXIX. This shows the fox with his tail in the water beset by a whole school of crayfish.

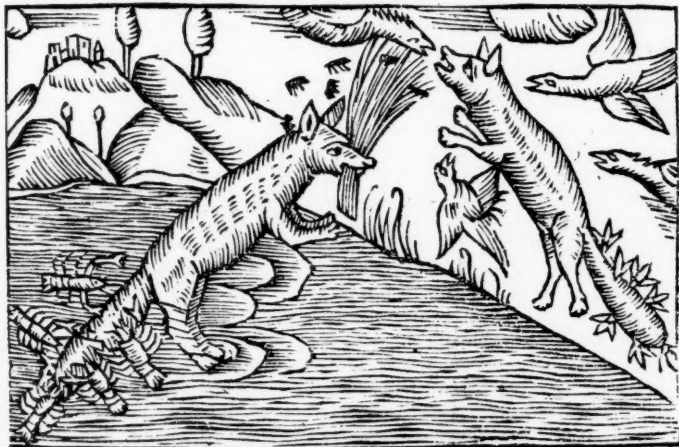


Fig. 3.—A fox (in Sweden) coming ashore with a catch of crayfishes attached to his tail. After Olaus Magnus, 1555

ceans, of which Reynard is inordinately fond. These, moreover, by reason of their clawed feet and by their spiny exoskeletons, are far more easily caught, it would seem, in the hairs than are fishes.

Olaus Magnus writes in the most casual way of this fishing as if it were a thing well known. But on the facing page (637) in his book he writes personally and definitely thus in Caput XL:

Among the shelving rocks of Norway I have seen a fox put his tail down into the water between the rocks and draw out several crabs and then devour them. This is not an unusual sight, since fishes do not cling to a thing which is let down, especially if it is hairy, as crabs do.

Note that the Archbishop of Sweden says "I have seen" cancri (crayfishes?) on the tails of foxes (no unusual sight) when they were withdrawn from the water. It is "going strong" to throw out as folklore the Archbishop's statement and figure of this fishing—a thing by no means physically impossible.

4. The Tail-fishing Fox in Norway (1752). For an account of Reynard fishing with his tail in Norway, we go to Erich Pontoppidan, who was Bishop of Bergen, and a member of the Royal Academy of Sciences in Copenhagen. Probably because of this membership, his book on the *Natural History of Norway* appeared in Danish in 1752 (two printings). It appeared in German in 1753 and in English at London in 1755. A copy of this last edition is in the library of the American Museum.

Of particular interest to us is Pontoppidan's account of the fox's fishing with its tail—from p. 22 in Part II of his folio tome (1755):

His long hairy tail, with which nature has not supply'd him in vain, he uses in Norway, amongst other purposes, to catch crabs [crayfishes?]. They are fond of anything hairy, and generally will lay hold of it; by which means he draws them ashore.

Here Pontoppidan speaks of this fishing as a matter known of all men. Unfortunately, he gives no figure of this fishing.

We must now leave the far past to return to the near present in our study of mammals alleged to use their tails in fishing. Unfortunately, there are no present-day accounts of the keen-witted fox doing such fishing. The account nearest us is of another animal. It follows next.

*The otter as a tail-fisherman.*—The otter is exceedingly fond of both fishes and crayfishes. It is well known that being amphibious he catches the former by diving, swimming and seizing them with his jaws. But that he catches the crayfishes with his tail seems to have been known to but one man.

In 1904, J. H. Perreau, under the pseudonym of Jho. Pâle, published a book on fishes and fishermen. One section of this is entitled *Les Pêches Bizarres*, and a sub-division of this (pp. 284-286) is sub-titled *La Pêche au Queues*. This was carefully translated. But, alas, "queues" were tails of a certain small fish with the heads removed and the "queues" impaled on hooks as bait and there was no word of animals fishing with their own "queues."

However, on page 287, opposite the ending of the sub-section noted, is a figure (No. 4 herein) bearing the caption "Loutre pêchant des écrevisses à l'aide de sa queue." This shows one otter with his tail immersed in the

stream and waiting for bites, while in the foreground is another complacently contemplating his tail much adorned with a school of crayfishes. But nowhere in the adjacent nor in the following text is there the slightest reference to the figure or to the otter or any other animal fishing with its tail. But the figure, however, does indicate that the otter was alleged to so fish, if we may take Perreau as an authority.

*Rats that use their tails in fishing.*—The rat, like the fox, is omnivorous, and in the struggle for existence, he has developed a keen brain and has worked out various efficient ways of getting his breakfast. But that he should go a-fishing, and above all, use his tail to catch his prey, is the last thing one would expect.

The one account thus far found is from the pen of C. A. W. Monckton, for years a government official in New Guinea and adjacent islands. His two books abound in many natural history observations. The one of most interest to us here now follows.

While on a trip to the Trobriand Islands, Monckton had a most interesting experience (1921, p. 46). He spent a night on a small coral island with a few stunted trees but no other vegetation. During the night he was disturbed by rats crawling over him. Next morning, while his breakfast was being prepared, he walked to the other side of the little island wondering what the rats could possibly find for food, since absolutely no land-grown food was available. While sitting there, he saw how the rats get their breakfasts. He writes thus:



Fig. 4.—Otters fishing with the tail. The one in the background is awaiting his prey, the one in the foreground with satisfaction contemplates his catch. After J. H. Perreau, 1904.

I noticed some rats going down to the edge of the reef—lank, hungry-looking brutes they were, with pink naked tails. I stopped on the point of throwing lumps of coral at them, out of curiosity to see what the vermin meant to do at the sea. Rat after rat picked a flatish lump of coral, squatted on the edge and dangled his tail in the water; suddenly one rat gave a violent leap of about a yard, and, as he landed, I saw a crab clinging to his tail. Turning around, the rat grabbed the crab and devoured it, and then returned to his stone; the while the other rats were repeating the same performance.

This behavior was not witnessed elsewhere, but there can be no doubt of its accuracy. Monckton was a scientific observer and one of the trusted lieutenants of Sir William MacGregor, the great British Governor of New Guinea.

*The raccoon as a tail-fisherman.*—The "little bear with the long tail" is known to be very fond of crayfishes. He is a pretty keen-witted beast and it may be that he fishes for them.

To my home town, Waynesville, in the high mountains of Western North Carolina, tourists have for years come in the summer—particularly from Florida and southern Georgia. In 1933, I met a tourist, who, learning that I was interested in all curious and unusual things in the natural history of animals, told me that Mr. C. E. Hines of Blanton, Florida, reported that he had seen a raccoon fishing with its tail. On my return to New York, I wrote to Mr. Hines about this fishing, and had a reply from which the following account is extracted.

Mr. Hines was out in a boat fishing in Moody Lake, where a small stream entered the lake, when he saw a most unusual thing. Of it he writes thus:

I saw a coon come down to the edge of the water and look around for something I did not know what. I sat still and watched him. Soon he got just in the edge of the small stream [flowing into the lake] and let his tail hang in the water and every few minutes he would give his tail a flirt and run out on the sand to pick up something and eat it. I watched it for a while and then eased the boat up nearer until I could see the small fishes that were thrown out of the water with the coon's tail, so I knew that he was really catching fish. This is the only time that I ever saw this done.

In 1934, Mr. Hines came to Waynesville and I met and talked with him several times about the "coon." He had nothing essential to add to his written statement since he never saw the animal again. However, it should be noted that there was nothing to indicate that he felt that he had told a "big tale" and "must make it stick." He was always very matter of fact about the occurrence.

How close Mr. Hines was when the coon flicked off the "fish," I did not think to ask. Now, in the light of what has been set down above about the fishing for crustaceans by bushy-tailed mammals, one wonders if the raccoon was not fishing for his favorite food—crayfishes.

*Does the coyote fish with his tail?*—Now we have reached (chronologically) the last account that has come to hand of a mammal fishing with its tail. The following statements are taken from J. Frank Dobie's comprehensive book on the coyote (1949).

It is widely known that, in the struggle for existence, the coyote, like his cousin the fox, has developed a keen intelligence—especially in matters of getting food. To show how the coyote obtains at least some of his fishes,

Dobie gives the following account, which ties up with Rodahl's recital of how the Greenland fox catches his finny prey.

Dobie states (p. 121) that "in 1939 two Texas game wardens saw a coyote scooping large minnows out of shallows in the Canadian River," and he adds that "on the Columbia River they have been seen slapping spawning salmon out of the water in the manner of bears."

Dobie (1949, p. 120) states that coyotes are very numerous on Padre Island on the Gulf coast of Texas. There "a fisherman without guile" told him that coyotes have stolen from him fish that he had staked out in water two feet deep to keep them fresh.

These accounts of how the coyote gets the fishes of which he is so fond make one wonder if he may not use his tail—this conjecture seems not impossible in the light of the statement in the next paragraph.

And now as this narrative began with the definite statement by Olaus Magnus (1555) that the fox catches crustaceans (crabs and crayfishes) with his tail, so Dobie (1949, p. 120) says that the coast-dwellers of Padre Island state that coyotes fish for shrimp and crabs with their tails. And for himself he says that—"it is certainly possible for a coyote to catch a crab on its tail."

The above citations from Dobie bring to an end the "alleged" accounts of mammals fishing with their tails—so far as this study has found. And it is now in order to make an attempt to evaluate them.

#### HOW MUCH WEIGHT DO ALL THESE ALLEGATIONS CARRY?

The accounts of using the tail for catching of fishes by seven terrestrial mammals have, in the preceding section, been carefully presented in the words of the writers, so far as possible. The accounts pertain to the fishing activities of these seven mammals (six of them small)—the jaguar and the house cat, the fox (three men), the otter, rats, the raccoon, and the coyote. These accounts of the seven mammal fishermen extend in time from 120 A.D. to 1949. They come from three continents—Europe, North and South America. The very considerable amount of the evidence causes one to recall the old saying—that "Where there is so much smoke, there must be some fire." However, one wishes that more of the men quoted were of the scientific competence of Monckton on the rat.

It is easy to see how the crustaceans are caught. With their clawed appendages, large and small, they lay hold on the hairs of the tail, then the spiny processes with which they are plentifully supplied get buried in the hairs and are securely held fast. So much so is this, that it is noted that the fox or coyote must swing its tail vigorously to set the crustaceans free on the land.

With the fishes, the holding fast is quite different. Some are spinose about the head and gillcovers. Such fishes will get a pretty sure entanglement in the hairs. Small, smooth-skinned fishes are likely to bury themselves deeply in the hairs as they would in thick-growing water weeds. These fishes give off slime from skin and scales, and this slime on a foreign body (an angler's sleeve, for instance) would tend to coagulate. If the little fishes snuggle in

among the hairs of the fox's tail, as one might expect them to do, this slime would tend to hold them fast. Then, too, since the hair and skin of the fox's tail have an animal odor and taste, it seems probable that the small fishes would take the hairs in their mouth, and thus securely hold fast—necessitating a vigorous shaking of the tail on shore to set the fishes free to be eaten.

There will now be interpolated herein an account of fishing by a large land bird to show how the little fishes snuggle in its feathers when the bird squats in the water. This will probably help make clear how the little fishes can snuggle amid the hairs of a bushy-tailed mammal.

*The fishing of the cassowary.*—This fishing bird is a member of the ostrich family. These struthious birds are dry-land dwellers, and it seems incredible that one of this group should go into the water and that it should go a-fishing therein—above all, essentially in the manner that is alleged for the fishing of the fox with its tail. The attested accounts of the fishing habits of this great bird are in the reports of two men published in articles in scientific journals of high standing and in one book. These accounts have been brought together in an article (Gudger, 1927). From this the following pertinent quotation is extracted in the belief that it will throw some light on the alleged fishing of the fox.

Wilfred Powell, a scientific explorer of standing, writes (Proceedings Zoological Society of London, 1880, p. 494) that, sitting in his boat on a river in New Britain, he made the following interesting observation:

I saw a Morroop (Cassowary) come down to the water's edge and stand for some minutes apparently watching the water carefully; it then stepped into the river where the water was about three feet deep, and partially squatting down, spread its wings out, submerging them, the feathers being spread and ruffled. The bird remained perfectly motionless; I also noticed that the eyes were closed as if asleep. It remained in this position for fully a quarter of an hour, when suddenly closing its wings and straightening its feathers,



Fig. 5.—The cassowary shakes himself to free the little fishes from his feathers. He then picks them up and swallows them. Drawn to illustrate Dr. Gudger's article, *How the Cassowary Goes A-fishing*, 1927.



it stepped out on to the bank, where, shaking itself several times a number of small fishes fell from under its wings and from amidst the feathers, which were immediately picked up and swallowed (Fig. 5 herein). The fishes had evidently mistaken the feathers for a description of weed that grows in the water along the banks of the rivers in this island, and very much resembles the feathers of the Cassowary, and in which the smaller fish hide to avoid the larger ones that prey on them.

If the little fishes hide thus in the cassowary's feathers (Fig. 5), it seems not a far cry to their doing likewise in the hairs of a fox's, coon's or coyote's bushy tail.

And now to those "doubting Thomases" who discount the recitals by non-scientific men that foxes, coons and coyotes catch little fishes and crayfishes with their hairy tails, let me set out the reaction of an eminent zoologist to something that seems equally as "preposterous." This man was Professor W. K. Brooks of the Johns Hopkins University.

#### HOLD IN ABEYANCE JUDGMENT OF THESE ALLEGATIONS WHILE WAITING FOR SCIENTIFIC EVIDENCE

In the spring of 1905, I reported in the Hopkins Biology Journal Club, an account from the *Bulletin Société Zoologique de France* for 1904 (pp. 143-147) an account of an unknown animal seen in Along Bay in French Indo-China and reported by an officer of a French war vessel. From its great length and sinuous vertical motions or folds, it was thought to be a sea-serpent. When I had finished with the article, I produced A. C. Oudemans' book, *The Great Sea-Serpent, an Historical and Critical Treatise*, London, 1893. In this book an enormous number of accounts from the earliest times down to date had been listed and an effort made to evaluate them, with the result that the author was a convert to the sea-serpent cult.

Then followed a deep and painful silence. Finally, someone plucked up courage to ask Professor Brooks what he thought of the allegation. His answer was a memorable one for me. He said that some years before (early 1890's) the Hopkins zoologists had a temporary summer laboratory in Jamaica. One day his children came up from the shore and reported that "there was a great big sausage" on the beach. Everything was dropped and all went to the beach to see—a gigantic squid egg case five or six feet long and with a diameter as great as that of a galvanized iron pail. Professor Brooks then said to us that at Beaufort, North Carolina, U. S. A., we had probably seen little six- or eight-inch squids and their egg case about two inches long and in size that of one's finger. Then he asked us to figure out the size of the giant that could produce a five- or six-foot egg case. Such giant squids had not up to that (Jamaica) time been reported. But since then Verrill has reported specimens stretching 40 or 50 feet, and recently I have seen a brief notice of one stretching 65 feet.—There are animals in the sea as large as the reputed sea-serpent.

Then Professor Brooks concluded with the statement, which has stayed with me all these years—"It is not safe to say that an animal does not exist

because our accounts of it come only from layman observers, and because no scientific man has yet seen, described and figured it. Keep an open mind." Then he added that "There is something in the sea behind all these serpent accounts and possibly some day the facts will come to light." His admonition was—"Keep an open mind while awaiting scientific evidence."

For myself, who has seen animals do some curious and unusual and unexpected things, I continuously urge that we do not throw out accounts of unusual behavior, not physically impossible, alleged of animals by layman observers only.

*Some other equally preposterous (?) behaviors.*—My Ph.D. thesis (published in 1905) described the pseudo-copulation of the pipefish, *Siphostoma floridae*.—In the U. S. Bureau of Fisheries Laboratory at Beaufort, North Carolina, U. S. A., on the evening of July 17, 1903, my shout, "Come quickly," brought all the investigators to see—the male and female pipefishes intertwined with genital orifices touching. The female extruded the eggs, the male fertilized them, and they slowly glided into the marsupium on the ventral side of the tail of the male. The preliminary *Liebespiel* and the slow filling of the pouch covers hours.

The conjecture about this process began with Aristotle (384-322 B.C.). A Frenchman had seen the transfer of eggs and had described it in the sea-horse, but I was the first man to see it in the pipefish. Had a non-scientific man so described it as above, he would have been laughed out of court.

In the years since the above behavior was recorded, I have seen and described how fishes do strange and unusual things, and have brought together from the scattered literature accounts of other such extraordinary behavior—that if these had been reported by non-scientifically trained men they would have been discarded as unworthy of belief. Thus for Rains of Fishes, the many early accounts were so hearsay, so lacking in details that they were laughed out of court. Some few years ago, a professor of English in Northwestern University, published an article in which he pronounced these alleged "Rains of Fishes" sheer myth and fable, and said in almost so many words that those who believed such fables were possessed of weak minds. He had read but the first of my then three historical articles on the subject.

In these other articles, I had brought forward the evidence of scientific men of high standing who had found the fishes on the ground or in receptacles near their houses; of some who had seen the fishes fall, and of others who had been out in the storms and had had the fishes fall on their hats and bodies. When these were reported to the English professor, that disbeliever confessed his ignorance and at least partially renounced what he had published.

So in the matter of mammals fishing with their bushy tails, it is not physically impossible and it may be a fact. Other behaviors of fishes and other animals, as seemingly improbable as this, and at first rejected, have eventually been seen and recorded by scientific men, so it seems best to hold our rejection of this in abeyance pending further evidence from scientific observers. Let us keep open minds.

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# A New Species of Acanthocephala From the Sunfish, *Lepomis gibbosus* (Linnaeus), With a Re- description of the Family Fessisen- tidae Van Cleave 1931\*

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During the course of a routine parasitological examination of twenty-six pumpkinseed sunfish from the "Old Reservoir" at Durham, New Hampshire, a single male acanthocephalan of the genus *Fessisentis* was recovered. Subsequent examination of three hundred and fifty-seven sunfish yielded five more worms, four of which were males. Comparison of stained whole mounts of these individuals with paratypes of *Fessisentis fessus* Van Cleave 1931, the only previously recognized representative of the genus, disclosed several distinct differences. Therefore, the present material is recognized as a new species which is here described under the name of *Fessisentis vancleavei*.

The family Fessisentidae was first established by Van Cleave in 1931 to include the single genus and species *F. fessus*. The original description was based on a long series of both male and female specimens taken from the freshwater drum, *Aplodinotus grunniens* at Money, Mississippi. According to Van Cleave (1931) no further report of this genus has been recorded. Consequently, the gap in geographical distribution occasioned by the recovery of the present material aroused more than passing interest.

The paucity of specimens in the present work is puzzling and may indicate that the sunfish in the "Old Reservoir" is not the normal definitive host for *F. vancleavei*. Preliminary examination of other species of fish from the same pond were negative for *Fessisentis* as well as for other Acanthocephala. The following fishes were checked: *Ameiurus nebulosus*—1, *Anguilla bostoniensis*—8, *Esox americanus*—15, *E. niger*—1, *Micropterus dolomieu*—19, *Notemigonus crysoleucas*—81. Smith (1948) stated that the present sunfish population of the "Old Reservoir" is traceable to twelve fish introduced in 1942. Yeager (1951) informed the writers that these fish were obtained from the nearby Oyster River. To date the fish in this river or in the headwaters at Wheelwright Pond have not been investigated for parasites.

Restricted seasonal occurrence might explain the small number of worms collected. This phenomenon has been noted previously in the Acanthocephala by Van Cleave (1916). He reported that *Gracilisentis gracilisentis* is present in the gizzard-shad of the Illinois River from early fall through late spring but is absent during the summer months. Conversely, *Tanaorhampus longirostris* parasitizes the gizzard-shad in the summer, reaches full sexual maturity by midwinter, and disappears entirely from spring to early

\* Contribution from the Zoology Department, University of New Hampshire.

summer. The writers plan to investigate this possibility during the ensuing months.

No attempt is made to explain the wide gap in the geographical distribution of *F. fessus* and *F. vancleavei*. It seems necessary to await further samplings of the area between Mississippi and the east coast for elucidation of this problem.

### *Fessisentis vancleavei* n. sp.

#### Figs. 1-4

*Specific description.*—Males about 5 to 8 mm. long; only female collected about 6 mm. long. Trunk devoid of spines. Proboscis of male and female nearly cylindrical in shape and approximately the same size, ranging from 355 to 365  $\mu$  in length by 96 to 107  $\mu$  in width. Hooks apparently arranged in 12 longitudinal rows of 8 or 9 hooks each. Third and fourth hooks from tip 33 to 49  $\mu$ ; basal row 22 to 33  $\mu$ . Male genitalia occupy about three-fourths the length of the body cavity. Male with four elongate, clavate cement glands. Testes confluent, long, and filiform. Proboscis receptacle sac-like with characteristic side wall composed of two muscular layers. About seven nuclei are located in the thickened outer wall at the posterior extremity of the receptacle. Approximately five more nuclei are associated with the inner wall at the posterior end of the receptacle. Single retinaculum. Lemnisci heavy and about the same length as the proboscis receptacle. No protonephridial organs on the uterine bell.\* Mature embryos in the female not available.

*Comparisons.*—*Fessisentis vancleavei* differs from *F. fessus* in having a longer, narrower, more nearly cylindrical proboscis. In *F. fessus* there are 12 to 16 longitudinal rows of 6 to 8 hooks each while in the new species there are 12 rows of 8 or 9 each. The anterior hooks of *F. vancleavei* are slightly smaller while the basal hooks are a little larger. The lemnisci are considerably shorter than those in *F. fessus*. The number of nuclei, within, and associated with, the thickened wall at the posterior extremity of the proboscis receptacle is greater in *F. vancleavei*. Both male and female *F. vancleavei* are somewhat smaller than male and female *F. fessus*.

*Type host.*—*Lepomis gibbosus* (Linnaeus) from Durham, New Hampshire. Incidence of infection very low. Intermediate hosts and developmental stages unknown.

*Type material.*—Holotype male and allotype female (No. 37353) deposited in the U. S. National Museum, Washington, D. C. A male paratype in the collection of H. J. Van Cleave, Urbana, Illinois. Male paratypes in the collection of A. J. Haley and W. L. Bullock, Durham, New Hampshire.

Van Cleave and Bullock (1950) reviewed the various criteria for proboscis measurements and indicated the diverse points of reference that have been used in determining proboscis length. They emphasized the importance and the advisability of adhering to a standard concept and suggested that of Lundström (1942) by which the posterior limit of the proboscis is determined by a line drawn through the hind edge of the basal plate of the last row of hooks. At the suggestion of Dr. H. J. Van Cleave this proboscis concept was applied to some of his *Fessisentis fessus* material as well as to *F. vancleavei*. The original description of *F. fessus* gave the proboscis length of females as 300 to 380  $\mu$  and described the male proboscis as being somewhat smaller. On the basis of six paratypes of *F. fessus* supplied by Dr. Van Cleave the following values were obtained. The proboscis of the females measured 315 to 325  $\mu$  long while the proboscis of the males was somewhat smaller, ranging in length from 225 to 250  $\mu$ .

Previous to the present work the family Fessisentidae comprised only the single genus and species *F. fessus*, with the generic and family characters being the same. Hence, the addition of *F. vancleavei* necessitated a reconsideration of these characters. The emended diagnosis is as follows.

\* In a private communication Van Cleave has stated that the structures interpreted as protonephridial units in the original description of *Fessisentis fessus* are anterior projections of cells of the selective apparatus. Consequently mention of protonephridial organs is omitted in the emended diagnosis of the family.

## Family FESSISSENTIDAE Van Cleave, 1931

*Diagnosis.*—Parasitic as adults in fresh-water fishes. Body elongate, devoid of spines. Proboscis short and clavate to nearly cylindrical, armed with numerous rather weak hooks. Proboscis receptacle an elongate double-walled sac bearing the brain in its posterior third. Retractors and single retinaculum penetrate near posterior extremity of the receptacle in which region the outer wall of the receptacle becomes much thickened. Lemnisci heavy, varying from about the same length as the proboscis receptacle to more than twice the length of the receptacle. Male organs occupy at least three-fourths of the length of the body cavity and comprise four elongate, clavate cement glands and two filiform testes.

*Type genus.*—*Fessissentis* Van Cleave, 1931, with the characters of the family.

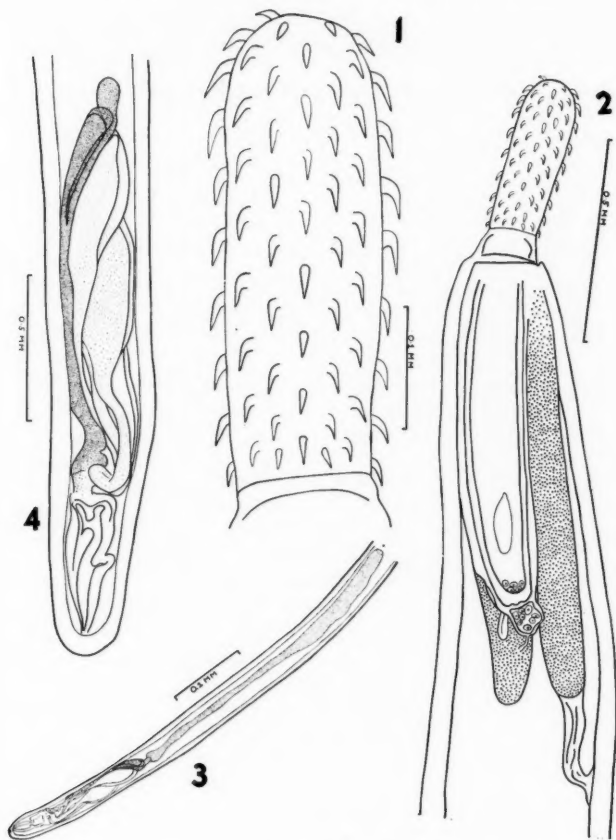
*Type species.*—*Fessissentis fessus* Van Cleave, 1931.

## ACKNOWLEDGEMENTS

The writers wish to express their appreciation to Dr. Harley J. Van Cleave for the loan of his personal slides for comparative study. Thanks are also extended to Professor C. F. Jackson and Mr. Paul H. Holle for aid in collecting the fish.

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Figs. 1-4. *Fessissentis vanleavei* n. sp.—1. Proboscis of the holotype male. Note the shape of the proboscis and shape and arrangement of the hooks. 2. Praesoma and anterior trunk of holotype. Note characteristic structure of proboscis receptacle and extent of the lemnisci. 3. Trunk of the holotype. Note confluent filiform testes and arrangement of other male reproductive structures. 4. Posterior portion of the holotype. Note structure and arrangement of the cement glands. All drawing made with a camera lucida from specimens stained in a modified Reynold's stain and mounted in Fisher Permunt.



## Studies on Monogenetic Trematodes. XV. Dactylogyridae from Alaska, Wisconsin, and Wyoming

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The material treated herein was collected from Wisconsin and Wyoming by Dr. R. V. Bangham of Wooster College, Wooster, Ohio; and from Alaska by Dr. R. L. Rausch, U. S. Public Health Service, Anchorage, Alaska, to whom the authors are grateful.

Available specimens up to a maximum of twenty were used in the treatment of each species. Only two Tetraonchinae namely, *Tetraonchus variabilis* from the round white fishes *Prosopium w. williamsoni* and *Prosopium cylindraceum quadrilaterale*, and *T. rauschi* from the grayling, *Thymallus signifer*, are new. The host distribution of the remaining nine species is as follows: *Cleidodiscus floridanus* and *C. pricei* from the channel cat, *Ictalurus l. lacustris*; *C. vancleavei* from the white crappie, *Pomoxis annularis*; *Murraytrema copulata* from the rosyside sucker, *Catostomus fecundus*; *Urocleidus chrysops* and *U. minus* from the white bass, *Lepibema chrysops*; *Dactylogyrus bulbosus* and *D. cornutus* from the common shiner, *Notropis cornutus frontalis*; and *D. extensus* from the carp, *Cyprinus carpio*.

The host material was first frozen and then preserved in five per cent formalin. The gills were placed in small vials about two thirds full of tap water and shaken vigorously in order to free the parasites from the branchial tissue. This material was then transferred to Syracuse watch glasses and diluted and decanted until sufficiently clear for reliable examination with a dissectoscope.

Specimens were transferred to clear water for removal of excess mucus. Each permanent mount was made by selecting a single specimen microscopically with a capillary pipette and transferring it to a drop of solidified glycerin-gelatin medium on a clean glass slide. A cover glass which was placed thereon settled in place as the medium was melted with gentle heat. The slide was then cooled, the medium congealed, and a permanent mount was thus produced.

Curved structures were measured as a straight line extending between the two most distant parts of such structures. Measurements of anchor lengths, for example, extend from the tip of the superficial root to the most distant point on the curved portion in the region of junction of the shaft and point. The width of the anchors is the greatest width of an anchor base. A mean measurement was calculated (in cases of two or more specimens) and consists of an average derived from the values for the same structure in different in-

dividuals. All measurements, except those for body length and width which were made under low-power, were accomplished with the use of an oil immersion objective.

Unless otherwise indicated the quotations used in the comparative descriptions are those given by the original authors. The outline of the haptor in many instances is given as including a number of sides; it is understood that the junction of the haptor with the peduncle is considered as one of these sides.

#### CLEIDODISCUS FLORIDANUS Mueller, 1936

*Host and locality*—*Ictalurus l. lacustris*, Upper Lake Pepin, Mississippi River, Wis.

*Previously reported hosts and localities*.—*Ameiurus melas*, Reelfoot Lake, Ridgely, Tenn. (Mizelle and Cronin, 1943). *Ictalurus furcatus*, Reelfoot Lake, Ridgely, Tenn. (Mizelle and Cronin, 1943). *Ictalurus l. lacustris*, St. Croix River, Burnett Co., and Upper Lake Pepin, Mississippi River, Wis. (Mizelle and Klucka, 1953). *Ictalurus lacustris punctatus*, Myakka River and Lake Okeechobee, Fla. (Mueller, 1936a), Reelfoot Lake, Ridgely, Tenn. (Mizelle and Cronin, 1943), St. Croix River, Burnett Co., and Upper Lake Pepin, Mississippi River, Wis. (Mizelle and Klucka, 1953). *Pilodictis olivaris*, Mississippi River (Mueller, 1937).

*Synonym*—*Cleidodiscus mirabilis* Mueller, 1937

*Specimens studied*—Seven

*Location*—Gills

*Comparative description*—Moderately large dactylogyrid provided with a thin, smooth cuticle; length 1.058 mm (0.846-1.566 mm). Greatest body width 0.14 mm (0.108-0.162 mm), usually present in the anterior portion of the body and frequently at the level of the copulatory complex. "In normal state of contraction about 0.7 mm long, 0.14 mm wide." Eye spots four, the posterior pair generally twice the size of the anterior pair, and as mentioned in previous papers (see above), the spatial relationships between members of individual pairs of eye spots are variable. Cephalic lobes prominent, head organs variable in number. Pharynx subovate in outline (dorsal view) and 0.048 mm (0.033-0.059 mm) in transverse diameter. "Pharynx large, 0.05 mm in diameter." Haptor irregularly hexagonal in outline; peduncle narrow and elongate. Anchors similar in size and shape and composed of 1) shallowly bifurcated bases, 2) solid shafts, and 3) solid points. Ventral anchor length 0.059 mm (0.05-0.067 mm), greatest width of base 0.029 mm (0.021-0.042 mm); dorsal anchor length 0.051 mm (0.038-0.067 mm), greatest width of base 0.024 mm (0.013-0.033 mm). "Large hooks equal in size and similar in shape, 0.058 mm in greatest straight dimension, with flat, undivided roots." Ventral and dorsal bars as previously described for *Cleidodiscus mirabilis* Mueller (1937, J, figs. 49, 50) and *C. floridanus* Mueller (1936a); pl. 57, fig. 16), with the exception of a single ventral bar which in one of the present specimens is broadly V-shaped with a dome-like structure on the anterior surface. Ventral bar length 0.073 mm (0.065-0.093 mm); dorsal bar length 0.071 mm (0.063-0.086 mm). "Supporting bars sub-equal, ventral about 0.074 mm in greatest dimension, dorsal 0.078 mm." Hooks fourteen in number, normal in arrangement (Mizelle 1938), and identical with those originally figured for *C. floridanus* (Mueller, 1936a), Pl. 57, fig. 16). Hook lengths 0.014-0.018 mm "about 0.018 mm long." Copulatory complex composed of a basally articulate cirrus and accessory piece. The cirrus differs in some specimens from those originally figured for *C. floridanus* Mueller (1936a), Pl. 57, figs. 17, 18), and *C. mirabilis* Mueller (1937, fig. 6) in that the distal end is not flared. Accessory piece extremely variable, and as previously described (Mueller, 1936a, Pl. 57, figs. 17, 18; Mueller, 1937, J, fig. 6). Cirrus length 0.068 mm (0.059-0.097 mm); accessory piece length 0.096 mm (0.076-0.101 mm). "The greatest straight line dimension of the cirrus is about 0.045 mm." Vitellaria consists of two lateral bands confluent anteriorly and posteriorly; reproductive organs obscured. Vagina, seminal vesicle and prostates not observed.

These observations support the contention of Mizelle and Cronin (1943) that *C. floridanus* and *C. mirabilis* are identical.

## CLEIDODISCUS PRICEI Mueller, 1936

*Host and locality*—*Ictalurus l. lacustris*, Upper Lake Pepin, Mississippi River, Wis.

*Previously reported hosts and localities*.—*Ameiurus melas*, Local Ponds and Streams near Stillwater, Okla. (Seamster, 1938); Baton Rouge, La. (Summers and Bennett, 1938); Reelfoot Lake, Ridgely, Tenn. (Mizelle and Cronin, 1943); Opeongo Lake, Algonquin Park, Ontario, Canada (Mizelle and Donahue, 1944); Swamp Pools near Tremont, La. (Seamster, 1948). *Ameiurus natalis*, Myakka River, Fla. and Lake Okeechobee, Fla. (Mueller, 1936a); Reelfoot Lake, Ridgely, Tenn. (Mizelle and Cronin, 1943). *Ameiurus nebulosus*, Myakka River, Fla., Lake Okeechobee, Fla. (Mueller, 1936a), Oneida Lake, N. Y. (Mueller, 1937); Dixon, Proulx, and Smoke Lakes (all) in Algonquin Park, Ontario, Canada (Mizelle and Donahue, 1944); Yellow River flowage next to Fisheries Laboratory near Spooner, Wis. (Mizelle and Regensberger, 1945); Westhampton Lake, University of Richmond, Va. (Hargis 1952, 1953). *Ictalurus furcatus* (LeSueur), Reelfoot Lake, Ridgely, Tenn. (Mizelle and Cronin, 1943). *Ictalurus l. lacustris*, Upper Lake Pepin, Mississippi River, Wis. (Mizelle and Klucka, 1953). *Ictalurus lacustris punctatus*, Myakka River, Fla., Lake Okeechobee, Fla. (Mueller, 1936a); Local Ponds and Streams near Stillwater, Okla. (Seamster, 1938); Reelfoot Lake, Ridgely, Tenn. (Mizelle and Cronin, 1943).

*Specimens studied*—Eight

*Location*—Gills

*Comparative description*—Moderately large species provided with a thin, smooth cuticle; length 0.567 mm (0.504-0.684 mm) "length 0.62 mm." Greatest body width 0.094 mm (0.084-0.122 mm) "0.14 mm," and located in the anterior third of the body. Eye spots four, the posterior pair one and one-half to two times the size of the anterior pair and somewhat closer together than the latter. Two specimens observed possessed abnormalities with respect to the eye spots. One specimen had three eye spots (one anterior, two posterior); another, two eye spots (one anterior, one posterior). Pharynx circular in outline (dorsal view) and 0.031 mm (0.025-0.036 mm) "0.04 mm," in transverse diameter. Cephalic lobes variable in size; head organs numerous and well developed. Peduncle of moderate size and narrower than body proper; haptor hexagonal in shape. Anchors morphologically similar, with well differentiated bases, solid recurved shafts and tips as recorded by Seamster (1938, figs. 1-3, 6, 7) and Mizelle and Cronin (1943, Pl. 1, figs. 65-72). Ventral anchor length 0.053 mm (0.047-0.058 mm), greatest width of base 0.024 mm (0.022-0.027 mm); dorsal anchor length 0.048 mm (0.045-0.052 mm), greatest width of base 0.023 mm (0.018-0.025 mm). "Greatest straight line measurement of a large hook, 0.048 mm." Bars dissimilar and variable. Ventral bar characterized by a sharp angle at the midportion and with rounded ends; dorsal bar with an ornate anterior surface and greatly variable as observed by Seamster (1938, figs. 1-3, 6, 7) and Mizelle and Cronin (1943, Pl. 1, figs. 51, 52). Ventral bar length 0.038 mm (0.036-0.043 mm); dorsal bar length 0.048 mm (0.043-0.054 mm). "Supporting bars subequal, dorsal bar 0.058 mm, ventral bar 0.05 mm." Hooks fourteen in number and normal in arrangement (Mizelle, 1938); hook lengths 0.012-0.016 mm "about 0.016 mm." Reproductive organs not observed. Vitellaria well developed as two lateral bands tending toward confluency throughout their extent. Copulatory complex as previously described by Mueller (1936a, Pl. 57, figs. 13-15). Cirrus length 0.035 mm (0.034-0.038 mm); accessory piece length 0.032 mm (0.03-0.034 mm). "Cirrus a thin walled chitinous tube, curved in an arc, its terminal end cut off at an angle. Measured in a straight line the cirrus is about 0.037 mm."

## CLEIDODISCUS VANCLEAVEI Mizelle, 1936

*Host and locality*—*Pomoxis annularis*, Mississippi River, Buffalo Co., Wis.

*Previously reported hosts and localities*.—*Pomoxis annularis*, Lake Decatur, Decatur, Ill. (Mizelle, 1936, 1938); Salt Fork of the Big Vermilion River, South of Oakwood, Ill., Boomer Creek, Stillwater, Okla. (Mizelle, 1938); Local Ponds and Streams near Stillwater, Okla. (Seamster, 1938); Baton Rouge and New Roads, La. (Summers and Bennett, 1938). Reelfoot Lake, Ridgely, Tenn., Mississippi River, in Illinois (Mizelle, LaGrave, O'Shaughnessy, 1943). *Pomoxis nigro-maculatus*, Lake Okeechobee, Clewiston, Fla. (Mueller, 1936a); Local Ponds and Streams near Stillwater, Okla. (Seamster,

1938); Lake Decatur, Decatur, Ill., Salt Fork of the Big Vermilion River, south of Oakwood, Ill., Boomer Creek, Stillwater, Okla. (Mizelle 1938); Reelfoot Lake, Ridgely, Tenn., Mississippi River, in Illinois, (Mizelle, LaGrave and O'Shaughnessy 1943); Westhampton Lake, University of Richmond, Va. (Hargis 1952, 1953).

*Synonym*—*Onchocleidus formosus* Mueller, 1936(a); *Cleidodiscus formosus* (Mueller, 1936) Price, 1937(a)

*Specimens studied*—Four

*Location*—Gills

*Comparative description*—Relatively small parasites with a smooth, moderately thick cuticle. Average body length 0.494 mm (0.431-0.626 mm) "length 0.563 mm (0.399-0.681 mm)"; greatest body width 0.063 mm (0.042-0.084 mm) "width average 0.07 mm (0.057-0.089 mm)". Cephalic lobes conspicuously developed; head organs numerous and well developed. Pharynx circular in outline (dorsal view) and 0.021 mm (0.016-0.025 mm) "0.025 mm (0.023-0.028 mm)" in transverse diameter. Eye spots four, anterior pair approximately one-half the size of the posterior pair and with members farther apart than those of the latter pair. Vitellaria well developed, obscuring the internal anatomy. Haptor hexagonal in outline; infrequently the posterior end is so narrow that the haptor appears pentagonal. "Haptor distinct, hexagonal in shape and broader than long." Peduncle short and narrower than body proper. Anchors similar in shape, the ventral anchor slightly longer than the dorsal. Anchors consisting of 1) slightly bifurcate bases, 2) solid shafts and 3) solid points. Ventral anchor length 0.047 mm (0.045-0.049 mm) "0.039 mm (0.033-0.044 mm)"; width of base 0.019 mm (0.018-0.02 mm) "0.019 mm (0.013-0.023 mm)". Dorsal anchor length 0.045 mm (0.041-0.047 mm) "0.036 mm (0.029-0.042 mm)"; width of base 0.012 mm "0.017 mm (0.015-0.019 mm)". Ventral and dorsal bars as previously described (Mizelle, 1938, figs. 38, 39). Ventral bar length 0.027 mm (0.025-0.029 mm) "0.024 mm (0.019-0.029 mm)"; dorsal bar length 0.025 mm (0.023-0.027 mm) "0.025 mm (0.019-0.029 mm)". Dorsal bar notched at each end and with a median spine on the posterior border. Ends of ventral bar variable in shape, median posterior spine present. Hooks fourteen in number and normal in arrangement (Mizelle, 1938). "Hook bases of pair number five ovate and shorter than shafts, bases of remaining hooks elongate. Bases of pair number one about same length as their shafts, bases of remaining hooks longer than their respective shafts." Hook pair No. 5 somewhat shorter than the others. Hook lengths: No. 1, 0.018 mm "0.018 mm"; No. 2, 0.018 mm "0.02 mm"; No. 3, 0.021 mm "0.019 mm"; No. 4, 0.021 mm "0.022 mm"; No. 5, 0.014 mm "0.013 mm"; No. 6, 0.02 mm "0.021 mm"; No. 7, 0.021 mm "0.024 mm". Gonads not observed. Copulatory complex as previously described (Mizelle, 1938, figs. 31, 32). "Cirrus a short chitinous tube, base relatively large, shaft tapered to a point distally." Cirrus length 0.02 (0.010-0.025 mm); accessory piece length 0.016 mm (0.012-0.025 mm). Vagina, seminal vesicle, and prostates not observed.

#### MURRAYTREMA COPULATA Mueller, 1938

*Host and locality*—*Castostomus secundus*, Spring Lake, Wyo.

*Previously reported hosts and localities*.—*Castostomus commersonii*, Chautauqua Lake and French Creek near Panama, N. Y. (Mueller, 1938). *Castostomus c. commersonii*, Silver Creek, Fond du Lac Co., St. Croix River, Burnett Co., Wis. (Mizelle and Klucka, 1953). *Hypentelium nigricans*, Chautauqua Lake and French Creek near Panama, N. Y. (Mueller, 1938). *Moxostoma anisurum*, Chautauqua Lake and French Creek near Panama, N. Y. (Mueller, 1938). *Moxostoma aureolum*, Silver Creek, Fond du Lac Co., St. Croix River, Burnett Co., Wis. (Mizelle and Klucka, 1953). *Moxostoma erythrurum*, Chautauqua Lake and French Creek near Panama, N. Y. (Mueller, 1938).

*Specimens studied*—Fourteen

*Location*—Gills

*Comparative description*—Moderately large form with thin, generally smooth cuticle; length 0.905 mm (0.756-1.08 mm), "from 1.5 to 3 mm". Greatest body width 0.19 mm (0.162-0.225 mm), "0.25 to 0.50", is present in the anterior third of the body. Eye spots four, posterior pair one and one-half to two times the size of the anterior pair and with members farther apart than those of the anterior pair; comprising melanistic

granules infrequently scattered. Cephalic lobes very weakly developed or absent; head organs small and few in number. Pharynx subcircular to ovate in outline (dorsal view) and 0.086 mm (0.071-0.101 mm) in transverse diameter. Peduncle narrow and comparatively short; haptor knob shaped. Anchors morphologically similar being composed of 1) a base usually without differentiated roots, 2) a solid shaft, and 3) a solid point. Infrequently the ventral anchor bases showed considerable bifurcation. Ventral anchor length 0.061 mm (0.058-0.072 mm), greatest width of base 0.029 mm (0.023-0.034 mm); dorsal anchor length 0.063 mm (0.060-0.073 mm). "Ventral and dorsal anchors approximately equal in length, 0.074 mm." The presence of one ventral bar and two dorsal bars is characteristic of this genus. The ventral bar consistently differed from previous descriptions (Mueller, 1938, Pl. 1, figs. 7, 13) in that the posterior border is provided with wing-like elevations. Ventral bar length 0.053 mm (0.044-0.063 mm); dorsal bars of approximately the same length 0.048 mm (0.042-0.052 mm) but slight variations were observed in some specimens. Hooks fourteen in number, of equal size, and small without inflated bases, as given by Mizelle and Klucka (1953). Hook arrangement typical of the genus; hook lengths 0.013 mm. Gonads not observed; vagina observed "in the ventral median area to the right of and slightly posterior to the cirrus" as observed by Mizelle and Klucka (1953). Vitellaria well developed, extending most of the body length, and confluent except in the midregion. Copulatory complex variable (Mueller, 1938, Pl. 1, figs. 11, 12) and consisting of a basally articulate cirrus and accessory piece; cirrus length 0.037 mm (0.029-0.041 mm), accessory piece length 0.034 mm (0.025-0.041 mm). Two prostate glands of unequal size observed at the base of the cirrus; seminal vesicle not observed.

### *Tetraonchus rauschi* n. sp.

*Host and locality*—*Thymallus signifer* Richardson, Anaktuvuk Pass, Alaska.

*Specimens studied*—Twenty

*Location*—Gills

*Type specimens*—Cotypes No. 48794, U. S. N. Helm. Coll., Beltsville, Md.

*Description*—Relatively large dactylogyrid provided with a cuticle which is thin or of moderate thickness and relatively smooth. Body length inclusive of haptor 1.801 mm (1.188-2.52 mm); greatest body width 0.247 mm (0.198-0.288 mm) and usually present in the anterior body half (exclusive of haptor). Cephalic lobes small and poorly defined or absent; head organs prominent but few in number. Eye spots four, members of the posterior pair invariably closer together than those of the anterior pair and from one and one-half to two and one-half times the size of the latter. Melanistic granules comprising the eye spots never greatly dispersed. Pharynx circular to ovate in outline (dorsal view); when ovate, the long axis may be longitudinal or transverse to the median body axis. Frequently the pharynx outline is broadly ovate posteriorly and more narrowly ovate anteriorly. Transverse diameter of pharynx 0.095 mm (0.071-0.114 mm). Peduncle slender and at times, extremely long; haptor broader than long and irregular in outline (dorsal view) and frequently produced into digitiform lobes in which individual haptoral hooks are isolated (fig. 1). Haptor width (greatest) 0.218 mm (0.156-0.262 mm), length 0.123 mm (0.105-0.169 mm). Haptoral bar usually associated with the dorsal pair of anchors in most North American freshwater genera, absent. Ventral bar well developed, varies from a butterfly-shaped structure to one which is H-shaped (figs. 21-25), and often accompanied by accessory centers of chitinization along its margin. Ventral bar length 0.062 mm (0.05-0.072 mm). Anchors four in number, similar morphologically, and consist of large bases and well-developed shafts and points (figs. 14-20). Anchor wings poorly developed and observed with difficulty. Bases of both pairs of anchors cleft approximately to the same extent and with superficial roots narrower than respective deep roots. Deep root of ventral anchor base invariably longer than superficial root; deep root of dorsal anchor base invariably longer than superficial root. Union of anchor shafts and bases frequently marked by a definite line. Anchor shafts and points unite without formation of an angle. Ventral anchor length 0.117 mm (0.101-0.135 mm), greatest width of base 0.053 mm (0.042-0.067 mm); dorsal anchor length 0.112 mm (0.093-0.139 mm), greatest width of base 0.052 mm (0.042-0.063 mm). Hooks sixteen in number and similar in size and shape. Each consists of 1) a short slender shaft

usually without an associated base, a sickle-shaped termination, 2) a decurved opposable piece, and 3) a posteriorly projecting structure approximately as long as the hook shaft (fig. 26). Members of hook pair number one situated on the ventral haptoral surface immediately anterior to the ventral bar; members of pairs numbers 2, 3, 4, and 5 situated bilaterally and consecutively on the anteroventral haptoral margin, number five being the most posterior; members of hook pair number six situated on the posterior haptoral border between the shafts of the dorsal anchors; members of hook pairs numbers seven and eight situated bilaterally on the dorso-posterior haptoral margin and lateral to those of number five, number eight being the most lateral. Hook lengths 0.014 mm. Gonads not observed with certainty. Vagina present on the ventral body surface immediately anterior to the yolk ducts, lightly chitinated, and continuous with a relatively large vaginal tube which is chitinated to the same degree. Seminal receptacle not observed. Vitellaria variable; usually consisting of two lateral bands as described by Mizelle (1938) for North American freshwater *Tetraonchinae* but may not be confluent posteriorly near the peduncle. In some specimens the vitellarial follicles are irregularly distributed over the body for the usual extent of the bands, i.e. from a point between the pharynx and the copulatory complex to the basal portion of the peduncle. In other specimens the vitellarial follicles extend as far forward as the anterior border of the pharynx and posteriorly into the peduncle. Copulatory complex consisting of a straight or curved tubular cirrus and a solid accessory piece of approximately the same length (figs. 2-13). Cirrus length 0.099 mm (0.082-0.112 mm); accessory piece length 0.101 mm (0.077-0.118 mm). Seminal vesicle and prostates not observed.

The closest relative of *Tetraonchus rauschi* n. sp. from the grayling, *Thymallus signifer* Richardson, is *T. monenteron* (Wagener, 1857), Diesing, 1858, which has been recovered only from *Esox lucius* Linnaeus (See Mizelle and Regensberger, 1945). Whereas the anchor wings and the relationship with reference to the length of the roots of the bases of both pairs of anchors are the same in the two species, those of *T. monenteron* are more slender and their bases are more deeply cleft than in *T. rauschi* (figs. 14-20 and Mizelle and Regensberger, 1945, Pl. 2, figs. 42, 43). The copulatory complexes are similar in the two species but they differ in that the naked base of the accessory piece in *T. monenteron* (Mizelle and Regensberger, 1945, fig. 37) is provided with a conspicuous projection in *T. rauschi* (figs. 8-13). The morphology of the hooks in the two species is similar but the distribution of these structures on the haptor is very different (see above discussion and Mizelle and Regensberger, 1945:693). The presence of a vagina in *T. rauschi*, the absence of such structure in *T. monenteron* together with a ventral bar whose morphology is different in the two species, further serve to separate these forms.

### *Tetraonchus variabilis* n. sp.

*Hosts and localities*—*Prosopium w. williamsoni* (Girard), Snake River, Wyo. and *Prosopium cylindraceum quadrilaterale*, (Richardson), Toluag Lake, Anaktuvuk Pass, Alaska.

*Specimens studied*—Twenty

*Location*—Gills

*Type specimens*—Cotypes Nos. 48795, 48796, U. S. N. Helm. Coll., Beltsville, Md.

*Description*—This very variable, relatively large dactylogyrid possesses a cuticle which varies from a thin, smooth condition to one which is relatively thick and moderately rugose. Body length inclusive of haptor, 1.558 mm (1.08-2.25 mm); greatest body width 0.334 mm (0.126-0.558 mm) and present at the midlength of the body proper (exclusive of haptor) or at a point immediately posterior to this region. Cephalic lobes small and poorly defined, or absent; head organs numerous and well defined. Eye spots four in number, members of the posterior pair invariably closer together than those of the anterior pair and approximately twice the size of the latter. Melanistic granules comprising a given eye spot, frequently so dispersed that the structure, as such, does not exist. In one apparently immature specimen this condition existed for all four of the eye spots; usually it was present for not more than two of the eye spots. This condition was at one time regarded as produced by excessive cover glass pressure (Mizelle, 1936) how-

ever, since dispersed granules of eye spots have been observed in live material, it is thought that this is a natural condition. That this is probably valid is supported by the fact that the present material was fixed before shipment to the laboratory. Pharynx circular or ovate (dorsal view) with the long axis longitudinal or occasionally transverse to the body axis; pharynx ovate in side view with the long axis disposed dorsoventrally; transverse diameter 0.115 mm (0.084-0.148 mm). Intestine not observed with certainty. Peduncle usually short and relatively broad; haptor broader than long and variable in outline. It may be irregularly pentagonal or subquadrate with the two sides constricted to produce two lateral lobes on each side (fig. 27). Haptor width 0.206 mm (0.139-0.258 mm), length 0.154 mm (0.105-0.211 mm). Haptoral bar usually associated with the dorsal pair of anchors in most North American freshwater genera, absent. Ventral bar highly variable and ranges from a well-developed structure through a vestigial condition, to complete absence in occasional specimens (figs. 43-48). Ventral bar length 0.03 mm (0.016-0.063 mm). Anchors four in number, similar in structure, and consist of broad bases and well-developed shafts and points. Anchor wings poorly developed and observed with difficulty. Superficial root narrower than deep root in bases of both pairs of anchors. Dorsal anchor base usually more deeply cleft than that of ventral anchors; roots of anchor bases of both pairs variable in length. In some cases the roots of the dorsal anchor bases are approximately the same length, in others the deep root is longer and in still others the superficial root is longer (figs. 40-42). This condition is the same for the ventral anchor bases but the deep roots are more frequently longer (figs. 36-39). In a few specimens which were apparently immature as indicated by the scant or non-existent vitellaria, the superficial roots of the ventral anchor bases were unusually short and are considered juvenile (fig. 37). Anchor shafts and bases unite at a definite constriction near which a spur-like projection often arises from the anchor base (figs. 36, 42). Anchor points and shafts unite without formation of an angle. Ventral anchor length 0.101 mm (0.076-0.135), greatest width of base 0.074 mm (0.063-0.08); dorsal anchor length 0.094 mm (0.076-0.105) greatest width of base 0.069 mm (0.059-0.08 mm). Hooks sixteen in number and of similar size and morphology. Each consists of a short slender shaft which may or may not be provided with an inconspicuous base, a sickle-shaped termination, a well-developed, decurved opposable piece, and a posteriorly projecting structure which appears inflated (fig. 49). Hook arrangement as described for *Tetraonchus monenteron* by Mizelle and Regensberger (1945) except that the terminal hook pair is situated between the shafts of the ventral anchors instead of at the level of the dorsal anchor shafts. Gonads situated near the body midlength. Ovary conspicuous, filled with large-nucleated eggs, and ovate to elongate-ovate in outline (dorsal view) with the long axis longitudinal or diagonal to that of the body; testis similar in outline to that of ovary and situated posterior or postero-dorsal to the latter. Vagina and seminal receptacle not observed. Vitellaria in mature specimens consist of two lateral bands of follicles which begin individually at a level between the copulatory complex and the posterior border of the pharynx, become confluent immediately anterior to the ovary (as the yolk ducts) and again near the base of the peduncle. Copulatory complex consisting of a tubular cirrus and an associated accessory piece (figs. 28-35); cirrus length 0.059 mm (0.041-0.063), accessory piece length 0.049 mm (0.036-0.058 mm). Seminal vesicle and prostates not observed.

The closest relative of *Tetraonchus variabilis* n. sp. from the round whitefishes, *Prosopium w. williamsoni* (Girard) and *Prosopium cylindraceum quadrilaterale* (Richardson), apparently, is *T. alaskensis* Price, 1937, which was recovered from *Salmo mykiss* Walbaum, *Salvelinus malma spectabilis* (Girard) and *Oncorhynchus kisutch* (Walbaum). Several concrete differences exist between the two species. Whereas in *T. alaskensis* the cirrus base is recurved and apparently proximally articulated with the relatively simple accessory piece, it is almost straight and is not basally articulated with the structurally more complicated cirrus in *T. variabilis* (figs. 28-35 and Price, 1937, fig. 11). The vitellarial bands in *T. alaskensis* are composed of well-circumscribed groups of follicles and are not confluent posteriorly (Price, 1937, fig. 11) whereas in *T. variabilis* the vitellaria follicles do not exist in circumscribed groups and the bands are confluent posteriorly. In addition the anchors in *T. alaskensis* are of much heavier proportions than in *T. variabilis*, the ventral bar differs markedly, and the arrangement of the haptoral hooks is different in the two species.



## UROCLEIDUS CHRYSOPS Mizelle and Klucka, 1953

*Host and localities*—*Lepibema chrysops*, Upper Lake Pepin and Mississippi River, Fountain City, Buffalo Co., Wis.

*Previously reported host and localities*—*Lepibema chrysops*, Upper Lake Pepin and Mississippi River, Wis. (Mizelle and Klucka, 1953).

*Specimens studied*—Seventeen

*Location*—Gills

*Comparative description*—Moderately small species having a thin, generally smooth cuticle. Body length 0.621 mm (0.533-0.828 mm) "0.609 mm (0.585-0.666 mm)"; greatest body width 0.113 mm (0.099-0.135 mm) and usually located in the anterior body third "greatest width 0.115 mm (0.099-0.141 mm)". Some specimens present approximately parallel lateral body outlines for the entire length while others taper considerably in a posterior direction. Eye spots four in number, members of the posterior pair one and one-half to two times as large as those of the anterior pair and farther apart than those of the latter. Cephalic lobes developed to different degrees. Head organs well-developed; pharynx circular in outline (dorsal view) and 0.03 mm (0.023-0.036 mm) "0.033 mm (0.03-0.036 mm)", in transverse diameter. Peduncle of moderate size; haptor characteristically hexagonal in outline. Anchors gently curved posteriorly in midportion and with enlarged ends, as observed by Mizelle and Klucka (1953); ventral anchors generally slightly larger. Anchor shape infrequently represented by more extreme angles than depicted by original authors (figs. 12, 13). Ventral anchor length 0.06 mm (0.054-0.067 mm) "0.065 mm (0.062-0.069 mm)"; greatest width of base 0.036 mm (0.021-0.038 mm) "0.033 mm (0.029-0.037 mm)". Dorsal anchor length 0.056 mm (0.049-0.058 mm) "0.059 mm (0.058-0.060 mm)"; greatest width of base 0.023 mm (0.018-0.03 mm) "0.025 mm." Anchor wings usually well-developed. Ventral bar as previously described (Mizelle and Klucka, 1953, figs. 7, 8) but with slight variation; one type consists of a straight structure, the other is of a definite V-shape. "Dorsal bar usually gently curved posteriorly in mid-portion and with enlarged ends" as observed by the original authors. Ventral bar length 0.052 mm (0.045-0.06 mm) "0.053 mm (0.049-0.056 mm)"; dorsal bar length 0.044 mm (0.038-0.049 mm) "0.046 mm." Hooks fourteen in number and normal in arrangement (Mizelle 1938). Structure of hooks consistent with description of the original authors (Mizelle and Klucka, 1953, figs. 9, 10, 11) as follows: "Base of hooks of pair number one developed to the extent of almost obliterating the hook shaft. Posteriorly projecting structure on base of sickle-shaped termination of hook not observed. Remaining hooks (except No. 5) with bases developed less extensively so that a short but definite shaft is present. Hooks of pair numbers one and seven longest. Hooks of pair number five shortest." Hook lengths: No. 1, 0.032 mm (0.025-0.036 mm) "0.035 mm (0.033-0.036 mm)"; No. 2, 0.022 mm (0.016-0.027 mm) "0.026 mm (0.025-0.027 mm)"; No. 3, 0.024 mm (0.016-0.027 mm) "0.026 mm (0.025-0.027 mm)"; No. 4, 0.024 mm (0.018-0.03 mm) "0.027 mm"; No. 5, 0.014 mm (0.01-0.02 mm) "0.018 mm"; No. 6, 0.025 mm (0.021-0.029 mm) "0.028 mm"; No. 7, 0.026 mm (0.021-0.031 mm) "0.033 mm (0.031-0.036 mm)." Gonads not observed. Vitellarian follicles in two lateral bands united broadly at the anterior and posterior ends, and narrowly so by the yolk ducts near the midlength of the body. Copulatory complex as originally described (Mizelle and Klucka, 1953, figs. 14-17); cirrus length 0.035 mm (0.029-0.043 mm) "length 0.040 mm," accessory piece length 0.028 mm (0.023-0.038 mm) "0.028 mm (0.027-0.029 mm)". Prostates and seminal vesicle not observed.

## UROCLEIDUS MIMUS (Mueller, 1936) Mizelle and Hughes, 1938

*Host and locality*—*Lepibema chrysops*, Mississippi River, Fountain City, Buffalo Co., Wis.

*Previously reported hosts and localities*—*Esox reticulatus*, London, O. (Mueller, 1936). *Lepibema chrysops*, London, O. (Mueller, 1936), Oneida Lake, N. Y. (Mueller, 1937) Lake Pepin, Mississippi River, Wis. (Mizelle and Klucka, 1953).

*Specimens studied*—Fourteen

*Location*—Gills

*Synonym*—*Oncholecidus mimus* Mueller, 1936

**Comparative description**—Relatively large species, 0.939 mm (0.774-1.098 mm) in length, provided with a very thin smooth cuticle. Greatest body width 0.149 mm (0.117-0.180 mm) and generally present in the anterior region. Eye spots four, members of the posterior pair nearly twice the size of those of the anterior pair and farther apart than the latter. Cephalic lobes poorly developed; head organs usually very strongly developed. Pharynx circular in outline (dorsal view) and 0.05 mm (0.042-0.059 mm) in transverse diameter. Peduncle between one fourth and one third of the total body length and less than one third of the greatest body width. Haptor generally hexagonal in outline. "Haptor broader than long, 0.07 x 0.05 mm." Anchors similar in size and shape; frequently, however, one pair may be slightly larger than the other. Ventral anchor length 0.038 mm (0.034-0.041 mm), greatest width of base 0.021 mm (0.016-0.028 mm); dorsal anchor length 0.036 mm (0.032-0.04 mm), greatest width of base 0.016 mm (0.012-0.02 mm). "Anchors with greatest dimension of 0.03 mm." Ventral bar larger than dorsal bar; bar shapes as previously described (Mueller, 1936, Pl. 13, fig. 13). Ventral bar length 0.04 mm (0.032-0.041 mm); dorsal bar length 0.032 mm (0.03-0.036 mm). Hooks fourteen in number, normal in arrangement; pair No. 1 consistently smallest; hook lengths: No. 1, 0.022 mm, remaining pairs 0.025-0.029 mm. Ovary ovate or pyriform in outline; testis elongate-ovate and situated posterior to the larger ovary. Vitellaria well developed, somewhat obscuring the internal anatomy in most specimens. Vitellarial bands confluent anteriorly and posteriorly; yolk ducts very weakly developed. Copulatory complex with an accessory piece not differing from that previously described by Mizelle and Klucka (1953, figs. 18, 19). Cirrus length 0.039 mm (0.034-0.047 mm) "0.07 mm"; accessory piece length 0.021 mm (0.018-0.028 mm). Prostates, vagina and seminal vesicle not observed.

This species was originally described (Mueller, 1936) and figured without an accessory piece. The presence of this structure supports the synonymy imposed on the old genus *Onchocleidus* Mueller, 1936, by Mizelle and Hughes (1938).

#### DACTYLOGYRUS BULBUS Mueller, 1938

**Host and locality**—*Notropis cornutus frontalis*, Fish Creek, Bayfield Co., Wis.

**Previously reported hosts and localities**—*Notropis cornutus frontalis*, Chautauqua Lake, N. Y. (Mueller, 1938), Proulx Lake in Algonquin Park, Ontario, Canada (Mizelle and Donahue, 1944), Fish Creek, Bayfield Co., Wis. (Mizelle and Klucka, 1953).

**Specimens studied**—Thirteen

**Location**—Gills

**Comparative description**—Relatively small dactylogyrid with a thin, smooth cuticle; length 0.384 mm (0.35-0.452 mm) "about 0.38 mm"; greatest body width 0.098 mm (0.076-0.118 mm) "0.02 mm," generally present in the posterior half of the parasite. Eye spots four, usually equal in size; occasionally members of the posterior pair are slightly larger; spatial relationship of eye spots variable. Anterior cephalic border divided medially; cephalic lobes conspicuous. Head organs numerous and well developed. Pharynx subcircular in outline (dorsal view) and 0.026 mm (0.023-0.03 mm) "0.026 mm" in transverse diameter. Vitellaria disposed as two lateral bands broadly united anteriorly and posteriorly. Haptor hexagonal in outline; peduncle non-existent, haptor and body proper separated by a constriction. Anchors consist of 1) a base with distinct superficial and deep roots 2) a solid shaft, and 3) a solid point as depicted by Mueller (1938, Pl. 3, fig. 26) and Mizelle and Klucka (1953, fig. 40). Anchor wings poorly developed and frequently not apparent. Anchor length 0.037 mm (0.03-0.041 mm) "about 0.035 mm"; greatest width of base 0.014 mm (0.009-0.018 mm). Dorsal bar with rounded ends and slightly arched in the mid-portion; dorsal bar length 0.023 mm (0.02-0.029 mm) "about 0.022 mm long." Vestigial ventral bar variable as described by Mizelle and Klucka (1953, figs. 42-44); in no specimen was it found as originally figured (Mueller, 1938, Pl. 3, fig. 25). Ventral bar measurement identical with dorsal. Hooks fourteen in number, normal in arrangement (Mizelle, 1938); hook lengths 0.019-0.02 mm. Reproductive organs not observed. Copulatory complex as originally described (Mueller, 1938), with the modifications described by Mizelle and Donahue (1944, figs. 21-23). Cirrus length 0.041 mm (0.034-0.047 mm); accessory piece length 0.03 mm (0.023-0.034 mm). Vagina, seminal vesicle and prostates not observed.

## DACTYLOGYRUS CORNUTUS Mueller, 1938

*Host and locality*—*Notropis cornutus frontalis*, Fish Creek, Bayfield Co., Wis.

*Previously reported host and localities*.—*Notropis cornutus frontalis*, Chautauqua Lake, N. Y. (Mueller, 1938), Proulx Lake, in Algonquin Park, Ontario, Canada (Mizelle and Donahue, 1944), Fish Creek, Bayfield Co., Wis. (Mizelle and Klucka, 1953).

*Specimens studied*—Four

*Location*—Gills

*Comparative description*—Relatively small forms provided with a very thin cuticle; length 0.423 mm (0.406-0.435 mm), greatest body width 0.099 mm (0.071-0.126 mm) "about 0.35 mm long by 0.08 mm wide." Four eye spots, members of each pair of equal size and equally spaced. Cephalic lobes well defined; head organs few in number. Pharynx ovate in dorsal outline and 0.029 mm (0.023-0.034 mm) "0.026 mm" in transverse diameter. Vitellaria well developed and extend from the posterior border of the pharynx into the peduncle. Peduncle short and thick; haptor roughly oval in outline. Anchors composed of 1) a base with well-differentiated roots, 2) a solid, evenly curved shaft, and 3) a solid point. Anchor length 0.038 mm (0.034-0.042 mm) "about 0.038 mm"; greatest width of base 0.017 mm (0.016-0.019 mm). Vestigial ventral bar length 0.024 mm; dorsal bar length 0.031 mm (0.03-0.032 mm) "about 0.03 mm." Shape of ventral bar different from that originally described (Mueller, 1938, Pl. 3, fig. 11) in that there is a large knob on the anterior surface, and the ends are bent posteriorly. Dorsal bar as originally described (Mueller, 1938, Pl. 3, fig. 10); length 0.031 mm (0.03-0.032 mm) "about 0.030 mm." Copulatory complex consisting of a cirrus which is a long, thin tube-like structure attached to an expanded base, and a short thick accessory piece. In each specimen the cirrus was evenly curved, describing a half circle. Previous reports have shown the cirrus to possess two angles of about ninety degrees (Mueller, 1938, Pl. 3, fig. 7; and Mizelle and Donahue, 1944, Pl. 2, fig. 51). Cirrus length 0.048 mm (0.042-0.05 mm); accessory piece length 0.016 mm (0.012-0.019 mm). Gonads not observed with certainty in the material available; vagina located on the right lateral margin slightly posterior to the copulatory complex. Seminal vesicle and prostates not observed.

## DACTYLOGYRUS EXTENSUS Mueller and Van Cleave, 1932

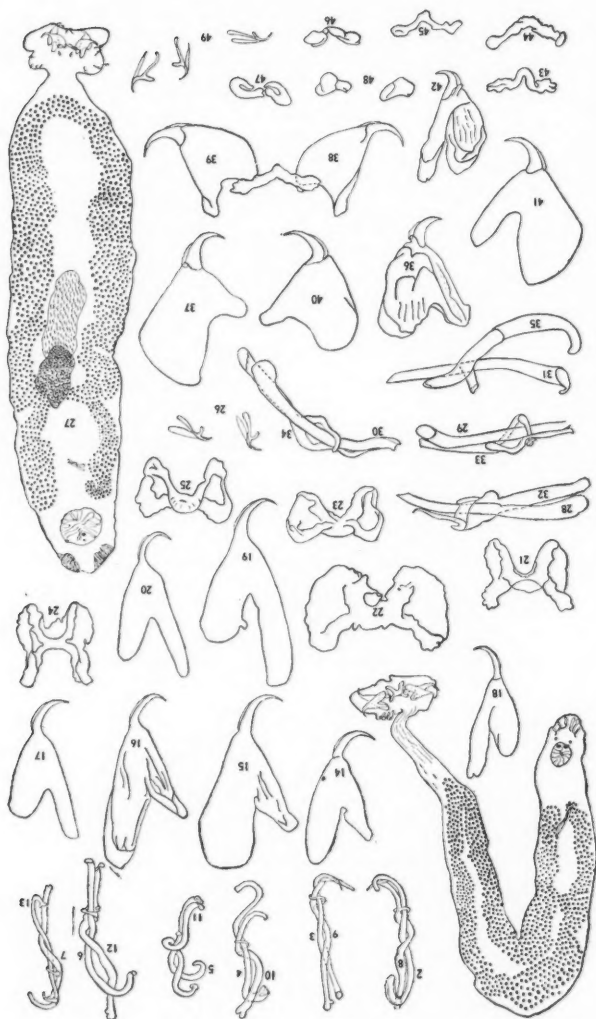
*Host and locality*—*Cyprinus carpio*, Lake Pepin, Wis.

*Previously reported host and localities*.—*Cyprinus carpio*, Oneida Lake, N. Y. (Mueller and Van Cleave, 1932), Lake Pepin, Wis. (Mizelle and Klucka, 1953).

*Specimens studied*—Twelve

*Location*—Gills

*Comparative description*—Relatively large parasite with a thick, transparent cuticle; length 1.08 mm (0.774-1.386 mm), "about 1.5 mm," greatest body width 0.147 mm (0.093-0.19 mm), "0.1 mm". Eye spots four, the posterior pair usually slightly larger than members of the anterior pair; spatial relationship of the eye spots equal. Cephalic lobes prominent; head organs numerous and generally divided into four distinct groups. Pharynx sub-circular in outline (dorsal view) and 0.042 mm (0.038-0.054 mm) in transverse diameter. Vitellaria well developed, extending from the region of the pharynx to the origin of the peduncle. Peduncle moderately long and rather broad; haptor irregularly hexagonal in outline. Anchors composed of 1) a deeply cleft base with well-differentiated roots 2) a solid shaft, and 3) a solid point. Each anchor with a perforation at the junction of the base and shaft; anchor wings poorly developed. Anchor length 0.085 mm (0.08-0.091 mm); greatest width of base 0.043 mm (0.04-0.051 mm). Dorsal bar thick with knobs on each end (Mizelle and Klucka, 1953, figs. 63, 64); dorsal bar length 0.045 mm (0.036-0.05 mm). Hooks fourteen in number and normal in arrangement (Mizelle, 1938); members of hook pair No. 5 consistently smaller than members of remaining pairs. Hook lengths: No. 5, 0.023 mm; other pairs 0.026-0.031 mm, "length of about 0.035 mm." Gonads obscured by the highly developed vitellaria; vagina on mid-dorsal surface, indistinct. Copulatory complex very large for the size of the parasite. Cirrus and accessory piece basally articulate; cirrus shaft long, with a short curve on the proximal end, accessory piece rather straight with a knob-shaped termination on the distal end. Cirrus length 0.078 mm (0.05-0.081 mm); accessory piece length



Figs. 1-49.—1-26. *Tetraonchus rauschi* n. sp. 1. Whole mount; 2-7. Cirri; 8-13. Accessory pieces; 14-16. Ventral anchors; 17-20. Dorsal anchors; 21-25. Bars; 26. Hooks. 27-49. *Tetraonchus variabilis* n. sp. 27 Whole mount; 28-31. Cirri; 32-35. Accessory pieces; 36-39. Ventral anchors; 40-42. Dorsal anchors; 43-48. Bars; 49. Hooks.

0.051 mm (0.043-0.056 mm). Seminal vesicle and prostates not observed in the present specimens.

*D. extensus* is one of the largest dactylogyrids recorded. It is readily distinguished from other forms by its characteristic dorsal bar and anchors. The copulatory complex is morphologically simple and resembles that of *Cleidodiscus pricei* of the subfamily *Tetraonchinae*. The cirrus and accessory piece were figured erroneously by Mueller and Van Cleave, 1932 (Pl. 18, fig. 13) (See also Mizelle and Klucka, 1953, figs. 65-67).

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## Vegetation of Haven Hill, Michigan

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Haven Hill Tract is located in the western part of Oakland County, Michigan, three miles east of the town of Highland. It occupies portions of White Lake and Highland townships and forms the easternmost part of the Highland Recreation Area, today administered by the Michigan Department of Conservation.

This tract, purchased for an estate by Edsel Ford in 1923, is completely fenced. The southern portion, with the exception of a few patches of timber and a few scattered lakes, consists mostly of fields formerly used for farm purposes. The northern portion (Fig. 1), however, has remained relatively undisturbed in recent years. Mr. Ford cut only a few trees, mostly cedar, from this section, to be used for fence posts. In 1924, shortly after his purchase, a small stream running through this area was dammed to create a large artificial lake, Haven Hill Lake, from a former marsh area.

Because of its varied topography this northern portion, largely covered with timber, contains many of the various types of natural areas to be found in Southern Michigan. Here one finds marshes, wet and dry fields, streams, lakes, ponds, tamarack and black spruce bogs, white cedar swamps, and swamp, oak-hickory, mixed-hardwood, and beech-maple forests. The distribution of these various vegetative communities is shown on the accompanying map (Fig. 1). It was primarily because of this diversity of plant communities that a botanical survey of the Haven Hill Tract was started in 1946 shortly after the Edsel Ford estate was purchased by the State.

*Topography.*—The surface features of the Haven Hill area were determined for the most part by the Wisconsin Glacier.<sup>1</sup> The Saginaw and Huron-Erie lobes of the glacier converged in this locality some 30,000 years ago, leaving as they receded huge irregular masses of glacial till to form the Interlobate Moraine. The rugged glacial hills and ridges of the Haven Hill Tract are a part of the extensive northeast-southwest moraine.<sup>2</sup>

The melt-waters flowing from the receding glacier collected and deposited sand and gravel over the lower ground to form extensive outwash plains. The flat areas found in the central and southwestern portions of the Haven Hill Tract adjacent to the morainal ridges are a part of the larger Commerce Outwash Plain.

Small ponds fill the numerous potholes found in the area. These de-

<sup>1</sup> Geo. M. Stanley, *Geology of the Cranbrook Area*. Bulletin No. 6 (1936), Cranbrook Institute of Science, Bloomfield Hills, Michigan.

<sup>2</sup> Jas. W. Bay, *Glacial History of the streams of Southeastern Michigan*. Bulletin No. 12 (1938), Cranbrook Institute of Science, Bloomfield Hills, Michigan.

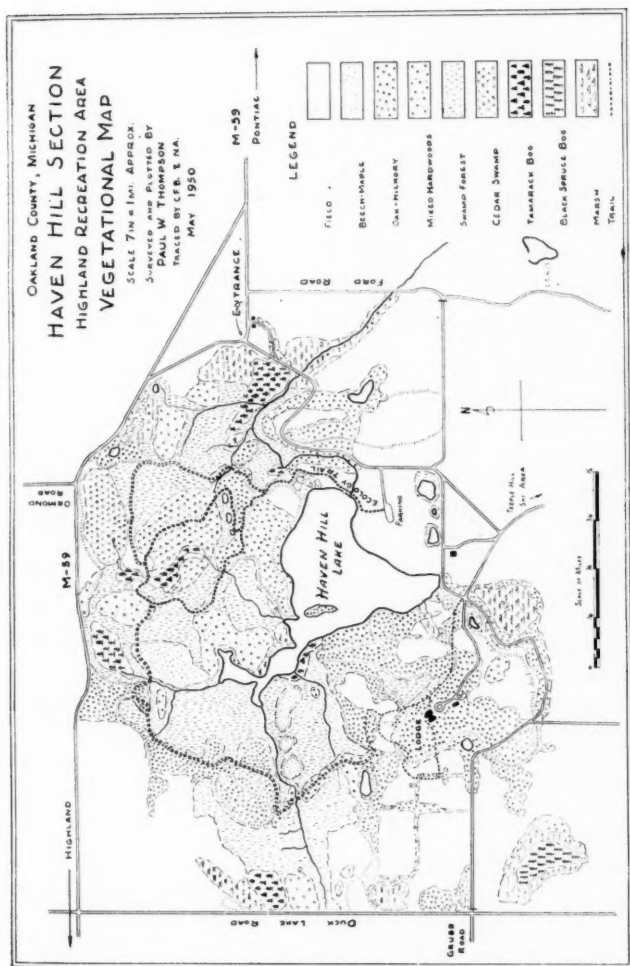


Fig. 1.—Vegetation map of Haven Hill, Michigan



pressions in the terrain were left by the melting of blocks of ice trapped in the glacial till.

**Oak-Hickory Forest.**—Oak-hickory forest covers most of the higher glacial ridges and hills. The dominant trees are the white and black oaks (*Quercus alba* and *Q. velutina*), the small pignut hickory, (*Carya ovalis*), and in smaller numbers several other species of upland hickories. The red maple (*Acer rubrum*), the ironwood (*Ostrya virginiana*), and red oak (*Quercus rubra*) are fairly common in places where the soil retains sufficient moisture. Beneath this forest canopy is a shrub layer in which the following species are conspicuous: witchhazel (*Hamamelis virginiana*), flowering dogwood (*Cornus florida*), shadbush (*Amelanchier* spp.), and maple-leaf viburnum (*Viburnum acerifolium*). In the early spring the most characteristic plants in the ground layer are the round-leaf hepatica (*Hepatica americana*), white trillium (*Trillium grandiflorum*), and the spring beauty (*Claytonia virginica*), to be followed later by the yellow violet (*Viola pubescens*), the may-apple (*Podophyllum peltatum*), the early sedge (*Carex pennsylvanica*), false Solomon seal (*Smilacina racemosa*), sarsaparilla (*Aralia nudicaulis*), and the wild geranium (*Geranium maculatum*). In summer these are replaced by the following species: large-leaf aster (*Aster macrophyllus*), large-leaf ticktrefoil (*Desmodium nudiflorum*), Indian pipe (*Monotropa uniflora*), and pinesap (*M. hypopithys*). The spotted coral-root (*Corallorhiza maculata*) is found occasionally.

**White Cedar Swamp.**—In the northern section of the Haven Hill area, on the low, flat ground, a white cedar swamp nestles between the high hills. This type of habitat is common in northern Michigan but rare in the southern part of the State. Its presence here may be explained by the protective influence of the surrounding hills and the slow drainage of this area as evidenced by the presence of bog iron.

The dominant trees in this community are the white cedar (*Thuja occidentalis*) and the yellow birch (*Betula lutea*). A few tall white pines (*Pinus strobus*) still remain scattered throughout this section. The most characteristic plants of such a habitat are the nude mitrewort (*Mitella nuda*) which forms a dense ground cover, alpine enchanter's nightshade (*Circaea alpina*), gold thread (*Coptis groenlandica*), and white violet (*Viola pallens*). Ferns such as (*Cystopteris bulbifera*) and various species of the wood fern (*Dryopteris* spp.) are plentiful. The bishop's cap (*Mitella diphylla*), and swamp saxifrage (*Saxifraga pennsylvanica*) are common. The most conspicuous shrubs are the red-berried elder (*Sambucus pubens*), the swamp currant (*Ribes triste*), and the dwarf raspberry (*Rubus pubescens*).

**Swamp Forest.**—The remaining low flat ground in this area is covered by an extensive swamp forest. The ground is quite damp and in spring is often partially covered with water. The high water table prevailing here is indicated by the very shallow root systems observed on uprooted trees. The principal tree species are black ash (*Fraxinus nigra*), white elm (*Ulmus americana*), and basswood (*Tilia americana*).

Although the leatherwood (*Dirca palustris*) is not a common shrub in

Southern Michigan, it is found in large number in this habitat, associated with other species of shrubs such as the spice bush (*Lindera benzoin*), and the high bush cranberry (*Viburnum trilobum*). A common ground shrub is the creeping wahoo (*Euonymus obovatus*).

In the spring such plants as the Douglass and white spring cress (*Cardamine douglassi* and *C. bulbosa*), the cutleaf and broadleaf toothwort (*Dentaria laciniata* and *D. diphylla*), Dutchman's breeches (*Dicentra cucullaria*), and blue cohosh (*Caulophyllum thalictroides*) appear. In this same habitat, later in the season, flourish the wood nettle (*Laportea canadensis*) and large specimens of the cinnamon, royal, and maidenhair fern (*Osmunda cinnamomea*, *O. regalis*, and *Adiantum pedatum*). Occasional stands of the shining clubmoss (*Lycopodium lucidulum*) grow in damp places. A rare plant of interest in this community is the ginseng (*Panax quinquefolius*).

As the ground rises from the lower areas to higher elevations, it is not uncommon to find large tulip trees (*Liriodendron tulipifera*) scattered along the transitional strip.

**Beech-Maple Forest.**—Beech-maple forest is a common association in Lower Michigan. In the Haven Hill Tract this forest community is situated chiefly on low "islands." These rise only a few feet above the wet surrounding plain which is covered by swamp forest. Although the beech (*Fagus grandifolia*) and the sugar maple (*Acer saccharum*) are the dominant species, the white ash (*Fraxinus americana*), black cherry (*Prunus serotina*), basswood (*Tilia americana*), and the red oak (*Quercus rubra*) are fairly common.

Growing in the dense shade supplied by the tree species, the shrub layer is rather sparse and is composed principally of transgressives and a few species such as the shadbush (*Amelanchier* sp.), leatherwood (*Dirca palustris*), and Canada honeysuckle (*Lonicera canadensis*).

In the spring the ground cover includes in profusion such species as the spring beauty (*Claytonia virginiana*), Canada violet (*Viola canadensis*), acute-leaf hepatica (*Hepatica acutiloba*), white trillium (*Trillium grandiflorum*), merry-bells (*Uvularia grandiflora*), yellow trout lily (*Erythronium americanum*), wild garlic (*Allium tricoccum*), yellow violet (*Viola pubescens*), and the broadleaf sedge (*Carex plantaginea*). A rare plant, the dwarf ginseng (*Panax trifolium*) grows locally in abundance. Only a few species of ground plants thrive in this area during the period that the trees are in full leaf.

**Mixed Hardwoods.**—This community consists of a mixture of the species found in the beech-maple association and in the oak-hickory forest.

**Tamarack Bog.**—Bogs, occupying several of the wetter areas where movement of the water is sluggish, are characterized by such species as the tamarack (*Larix laricina*) and poison sumac (*Rhus vernix*). The bog birch (*Betula glandulosa*), the high bush blueberry (*Vaccinium corymbosum*), and dwarf raspberry (*Rubus pubescens*) are often found scattered throughout a ground cover of sphagnum moss or other hydric mosses. Distinctive plants which are found in such a habitat are: pitcher plant (*Sarracena pur-*

*purea*), bog shinleaf (*Pyrola asarifolia*), tufted loosestrife (*Lysimachia thyrsiflora*), the white violet and bog violet (*Viola pallens* and *V. cucullata*).

**Black Spruce Bog.**—This habitat often included some of the same species of plants found in the tamarack bog. But the black spruce (*Picea mariana*) is the dominant tree. The sphagnum moss carpet is generally quite thick. In the more open spots there are often dense stands of leatherleaf (*Chamaedaphne calyculata*), sometimes mixed with high bush blueberry (*Vaccinium corymbosum*) and Michigan holly (*Ilex verticillata*). There is an occasional white birch (*Betula papyrifera*). On the drier hummocks are wintergreen (*Gaultheria procumbens*), cranberry (*Vaccinium macrocarpon*), creeping snowberry (*Gaultheria hispida*), and twinflower (*Linnaea borealis*). The starflower (*Trientalis borealis*), sundew (*Drosera rotundifolia*), and moccasin flower (*Cypripedium acaule*) are infrequent.

**Meadows.**—In this community the dominant species are grasses such as *Poa pratensis*, *Dactylis glomerata* and *Agropyron repens*. Where the soil contains considerable clay, white sweet clover (*Melilotus alba*) is plentiful. Other common species are: Wild bergamot (*Monarda fistulosa*), early goldenrod (*Solidago juncea*), gray goldenrod (*S. nemoralis*), wild carrot (*Daucus carota*), ox-eye daisy (*Chrysanthemum leucanthemum*), brown-eyed susan (*Rudbeckia hirta*), long-haired hawkweed (*Hieracium longipilum*), daisy fleabane (*Erigeron annuus*), pinweed (*Lechea villosa*), and St. John's wort (*Hypericum perforatum*).

The dewberry (*Rubus flagellaris*) and blackberry (*R. allegheniensis*) are often found in such dry meadows. *Juniperus virginiana* and the low juniper (*Juniperus communis* var. *depressa*) are occasionally found. On the borders of these open meadows the invading species are the black cherry (*Prunus serotina*), and hairy sumac (*Rhus typhina*). Many fields contain large numbers of the following plants: star thistle (*Centaurea maculosa*), yellow sweet clover (*Melilotus officinalis*), purple clover (*Trifolium pratense*), pink clover (*T. hybridum*), alfalfa (*Medicago sativa*), and silver cinquefoil (*Potentilla argentea*).

On the other hand, the vegetation of the wet meadows is quite different in composition. Rushes (*Juncus* spp.) and sedges (*Carex* spp.) are the dominant species. Scattered among these are the boneset (*Eupatorium perfoliatum*), Joe-pye weed (*E. maculatum*), jewelweed (*Impatiens capensis*), grassleaf goldenrod (*Solidago graminifolia* var. *nutallii*), and Indian hemp (*Apocynum cannabinum*).

**Marsh.**—Bordering streams and ponds in areas of shallow water the cattail marsh is a common occurrence. The cattail (*Typha latifolia*) often far outnumbers any other species. However, the shrubby cinquefoil (*Potentilla fruticosa*), duckweed (*Lemna* spp.), marsh marigold (*Caltha palustris*), and various species of sedges (*Carex* spp.) may be found also. The red-ozier dogwood (*Cornus stolonifera*), gray dogwood (*C. paniculata*), and various species of willows (*Salix* spp.) frequently border the marsh habitat.

**Lake, Pond and Stream.**—Haven Hill Lake, although artificial, contains

aquatic vegetation in such abundance that navigating a boat is a difficult process. The more common species are coontail (*Ceratophyllum demersum*), wild celery (*Valisneria americana*), water milfoil (*Myriophyllum* sp.), pondweed (*Potamogeton natans*), water lily (*Nymphaea tuberosa*), yellow pond lily (*Nuphar variegatum*), and water crowfoot (*Ranunculus longirostris*). Because of the manner of flooding, this lake lacks the normal shore and the associated shoreline flora to be found at Teeple Lake. However, the swamp loosestrife (*Decodon verticillatus*) is abundant along the low banks.

Teeple Hill Lake is the only other lake of any size in this tract. Bulrushes, rushes and sedges are common in the shallower water. One of the conspicuous plants is the pickerelweed (*Pontederia cordata*). Along the shores are found various mints, grass of Parnassus (*Parnassia glauca*), gentian (*Gentiana procera*), monkeyflower (*Mimulus ringens*), and many other species.

A variety of these same aquatic and semi-aquatic species thrive along the streams and numerous small ponds or potholes in this area.

Because of the diverse terrains, the Haven Hill area offers to the biologist a wide variety of plant habitats. This tract is unique because it encompasses in a relatively small area many of the common plant communities occurring in Southern Michigan. To take advantage of this feature the Southeastern Chapter of the Michigan Botanical Club, in cooperation with the Michigan Department of Conservation, a few years ago, constructed an Ecology Trail which is shown on the accompanying map.

I wish to thank Dr. Stanley A. Cain for his advice and encouragement in this project and to acknowledge the assistance of Mr. Chas. F. Boehler and Mrs. Nora Peisner in the preparation of the vegetational map from the original field map.

## Gross Modifications in Certain Plant Species Tolerant of Calcium Sulfate Dunes<sup>1</sup>

Lora Mangum Shields

*New Mexico Highlands University, Las Vegas*

The survival of vegetation in dune regions ordinarily depends upon a species plasticity which permits one or more of several possible adjustments to moving sand. A dune tolerant plant can usually endure temporary complete or permanent partial burial of the crown, elongate beyond accumulating drifts, greatly increase absorptive surface, withstand extensive exposure of the root system, or check the undermining action of wind erosion. Burial of vegetation, which usually results in defoliation and death, in certain plant species causes stem elongation which keeps young foliar portions of the crown sufficiently above the sand surface for survival. Such stems ordinarily produce adventitious roots at any level covered by moist sand. Certain species anchor the drifting substrate by a tangled growth of stems or roots. A number survive by the meristematic activity of creeping rhizomes. A few, chiefly the annuals, propagate successfully on and between the dunes by seed alone.

The present study was initiated to discover gross modifications, especially in the main axes, of plant species growing in the nitrogen deficient gypsum dunes of the White Sands south and west of Alamogordo, New Mexico, and to compare this flora with that of certain quartz sand dunes.

*Locale.*—This drifting gypsum deposit, which covers approximately 224 square miles, differs from the usual dune area in that the substrate is 96.97% calcium sulfate (Coville and MacDougal, 1903; Byers, 1936). Over a range approximately 28 miles long and 8 to 10 miles wide brilliantly white dunes 20 to 40 feet high alternate with narrow, wind-formed hollows. Windward slopes are long, rising gently at about a 30° angle, while leeward slopes are formed by sand slipping over the dune crests and settling at an angle of approximately 70°. The darker, lighter weight impurities are blown free of the drifts where the winnowed gypsum, being heavier, remains. The water table in the flats lies 2 to 3 feet below the surface, and the pH of the substrate is 7.5 (Byers, 1936). Only one of the several soil chemists who have analyzed this gypsum sand reports any trace of nitrogen. Quantitative tests also indicate insufficient amounts of potassium and phosphorus for normal plant growth.

*Evolution of the dunes.*—The White Sands lie in the Tularosa basin, which at this point contains gypsum carried from the Chupadora formation in the mountains on either side and deposited as valley fill, much of it in standing water, to a depth of 1000 feet (Potter, 1938). Gypsum forming the gradually growing dunes continues to be derived by wind excavation of an adjacent alkali flat, which represents the surface of the original de-

<sup>1</sup> This investigation was made possible by a grant from the Society of Sigma Xi.



Figs. 1-4.—1. *Sporobolus* spp. and *Chrysothamnus nauseosus* var. *latisquameus* in peripheral interdunal depressions; 2. *Yucca elata* buried except for inflorescence by an annual 9' increase in dune width; 3. Main axis of *Rhus trilobata* stabilizing gypsum mound 10' high (meter stick shown against hummock); 4. *Poliomintha incana* roots and stems binding gypsum hummock 13' high.

posit, supplemented by the gypsum washed in by each rain, and by that carried upward from lower levels by capillarity.

*Vegetation of the gypsum sands.*—Driven by the prevailing southwesterly wind, the gypsum dunes encroach slowly upon the desert plain adjacent on the north and east, which tends gradually to become denuded where the sand spills over its margins. The plant population remaining in the calcium sulfate deposit consists entirely of species capable of adjusting temporarily or permanently to a moving, drifting substrate (Fig. 1), including chiefly marginal survivors which originally grew in the area, plus 4 well established invaders occurring infrequently, if at all, in the surrounding country. One gymnosperm, between 44 and 50 dicotyledon species, and 15 monocotyledons appear in the sparse fringe of typically desert or halophytic vegetation along the bases of marginal dunes and in peripheral flats. Leaves of the dicotyledons exhibit several different combinations of xeromorphic and succulent characteristics (Shields, 1951). Only one dicotyledon, *Populus wislizeni*, attains tree-like proportions, 11 dicotyledons and 1 gymnosperm are shrubs, and the monocotyledons include 13 grasses, 1 sedge, and the shrubby *Yucca elata* (Figs. 2, 6). A few grasses and shrubby xerophytes dominate the vegetation of the most thickly populated interdunal depressions.

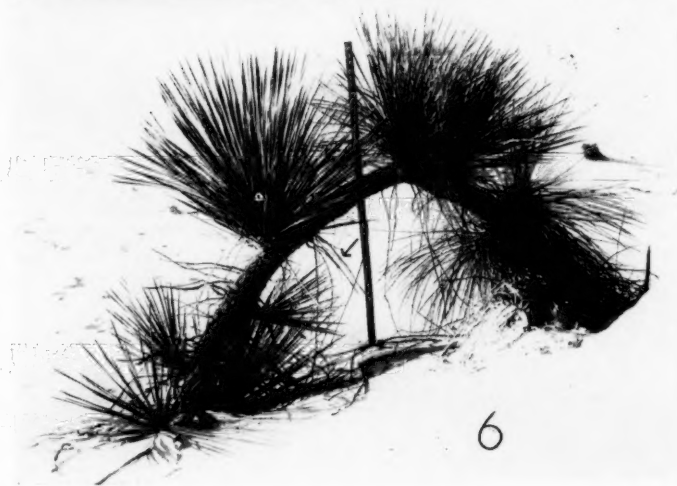
Plant growth in peripheral dunes and flats represents a large fraction of the climax vegetation on the adjacent desert plain subjected to the selective action of advancing gypsum sand, resulting in the complete displacement of 28 species which grow in the adjacent area (Schaffner, 1948). Conversely, at least 2 plants, *Populus wislizeni* and *Comandra pallida*, grow in the gypsum deposit, but not in the surrounding desert plains. *Abronia angustifolia*, the one dicotyledon found in the interdunal depressions farthest within the sands, and *Rhus trilobata*, most frequently responsible for hummock formation in the peripheral areas, appear sparsely, if at all, in the surrounding country (Schaffner, 1948). Several species which originate on the flats survive in the dunes by elongating beyond the drifts and producing adventitious roots at any level where moist sand banks about the main stems (Emerson, 1935). *Oryzopsis hymenoides*, a survivor of the plains, along with *Abronia angustifolia*, both annuals, appear farthest within the older interdunal blowouts. The only detectible plant succession within the sand deposit is the retrogression evidenced from the periphery inward. Probably wind erosion and dune movement are the selective factors which exert the greatest influence on plant survival in this environment.

*Wind action on vegetation of the White Sands.*—a. *Burial and uncovering:* While most of the drifts are fairly well stabilized, moving a few inches to a few feet each year, vegetation covers the faces of only the fore-dunes. Because of the selective denuding action of the accumulating gypsum, the plant population changes rather abruptly in density and variety of species between the peripheral and inner flats. Some of the vegetation of the original desert plain is destroyed at once by partial burial, while other species adapt temporarily or permanently.

In general, vegetation is too sparse to obstruct wind action, but several species having a thick crown of leaves and branches or closely grouped



stems contribute to their own burial by anchoring the drifting substrate. In a number of desert shrubs growth proceeds too slowly to permit elongation beyond the sand gradually being deposited by wind. Eight perennials grow-



Figs. 5, 6.—5. *Atriplex canescens* on 10' disintegrating hummock stabilized chiefly by roots (meter stick shown); 6. *Yucca elata* in wake of advancing dunes exhibiting new growth. Arrow indicates adventitious roots.

ing in the gypsum, however, which may serve as nuclei for sand deposition, survive almost complete burial by meristematic activity of the stem tips. The 5 of these species most efficient in stabilizing the substrate are *Rhus trilobata* (Fig. 3), *Poliomintha incana* (Fig. 4), *Atriplex canescens* (Fig. 5), *Yucca elata* (Fig. 6), and *Populus wislizeni* (Fig. 20). As a dune gradually recedes in height, occasional plants of these 5 species remain behind, their visible portions elevated on pillars of hardened gypsum bound by branching root systems, stems or adventitious roots. These temporarily secured mounds, which are often 9-12 feet high and 10-18 feet thick, are only gradually dissipated by wind. The present hummocks are held chiefly by compactly grouped stems of *Rhus trilobata*, by stems and basal leaves of *Yucca elata*, by both stems and roots of *Poliomintha incana* and *Populus wislizeni*, and largely by roots of *Atriplex canescens*.

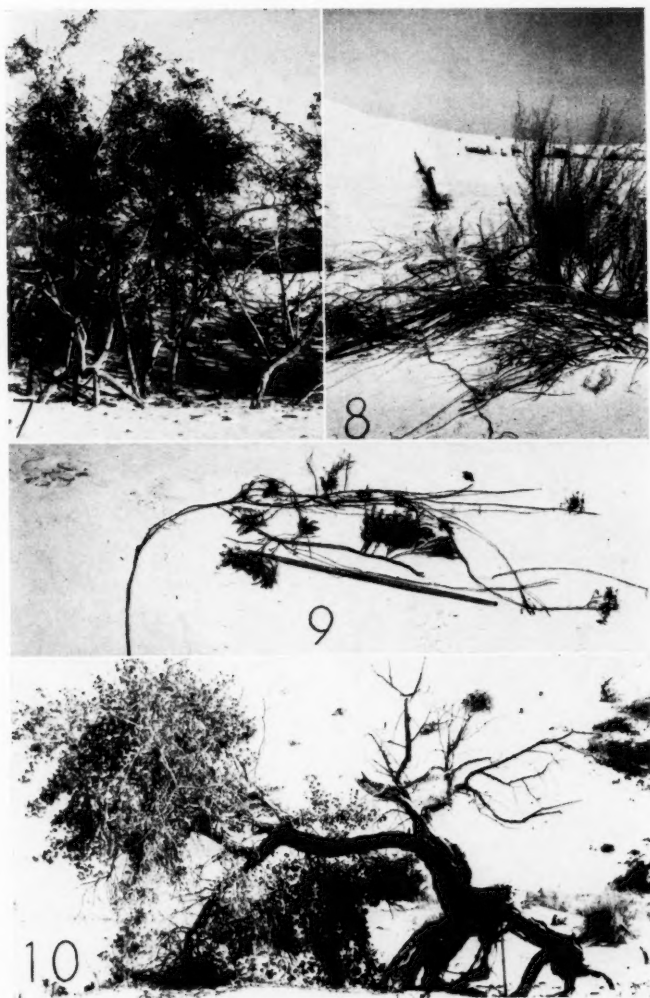
That three of these plants ordinarily originate on the flats and survive burial by elongating beyond the drifts is evidenced by grotesque *Yucca* stalks, covered by adventitious roots, left standing or variously bent behind receding dunes (Fig. 6), and by individual prostrate stems of *Poliomintha incana*, buried for a time, but remaining alive when dunes moved on, measuring 2 meters in horizontal length (Fig. 8). Young *Poliomintha incana* stems normally grow vertically, rarely attaining a height of more than 1 meter, but those left by drift movement, in contrast, are prostrate and twice the length of those grown under usual environmental conditions.

*Comandra pallida*, believed to be partially parasitic on cottonwood roots, survives burial on the advancing dune face through meristematic activity of an extensive rhizome system (Fig. 9). Propagation in this species and its creeping invasion of slope faces are chiefly vegetative by means of these rhizomes.

Individual plants of *Populus wislizeni* surviving in the flats exhibit distortions as evidence of burial or successive burials which often bend younger parts horizontally or at an even more acute angle downwardly (Figs. 10, 11, 12), but which stimulate upward growth at the exposed branch tips and the production of adventitious roots at intervals along the main trunks and larger branches. Occasional cottonwoods originating on the dune faces or in the flats for a time stabilize the sand about their stems and roots. Most of the cottonwoods in any particular flat and those of the adjacent dunes arise vegetatively from a common, shallow, horizontally oriented secondary root system which in many places is partially exposed by wind action.

*Ephedra torreyana* (Fig. 13) and *Chrysothamnus nauseosus* var. *latiquameus* (Fig. 14) stabilize only small mounds in the outer, younger flats. Except for these 8 dune tolerant species the White Sand vegetation does not ordinarily survive burial, but occurs chiefly in the flats, escapes extinction largely by seed propagation, and shows no specific adaptations to wind action.

b. *Sandblasting*: During several spring months the vegetation is blasted by high winds burdened with sand. Soil particles in transit injure plants directly by abrasion and sometimes decorticate stems and exposed roots on



Figs. 7-10.—7. Clustered shoots of *Rhus trilobata* behind advancing dune; 8. Prostrate stems of *Poliomintha incana* exposed by drift movement; 9. Short lengths of the extensive rhizome system by which *Comandra pallida* advances beyond growing drifts and spreads vegetatively over dunes and interdunal depressions; 10. *Populus wislizeni* distorted by burial under drifting sand.

the windward side. Injuries are most severe within 2 feet of the ground, drifting sand rarely rising high above the surface. The mechanical injury by wind is accompanied by a drying action contributing to the xeric atmospheric conditions.

*Modifications of root systems.*—Extensive root development is characteristic of the shrubby species which survive in the inner dunes. Vertical tap



Figs. 11-13.—11, 12, *Populus wislizeni* trunks bent in early growth by the weight of drifts; 13, Tap roots of *Ephedra torreyana* exposed by wind action.

roots extend deeply into the sandy soil, and lateral roots run beyond the limits of individual mounds. The extent of shallow underground parts is frequently made evident by wind erosion which in places exposes on the sand surface *Ephedra torreyana* roots 4 meters long, *Poliomintha incana*



Figs. 14-16.—14. Small hummock held by *Chrysothamnus nauseosus* var. *latisquamis*. Note effect of sandblasting on stems; 15, 16. Adventitious roots formed on buried trunks of *Populus wislizeni*.

roots 7 meters in length, and *Yucca elata* roots measuring  $2\frac{1}{2}$  meters.

Adventitious roots, in addition to increasing absorptive area, diminish the distance water need travel in reaching the plant apex. Adventitious roots of *Populus wislizeni* are larger (Figs. 15, 16), but are less numerous and conspicuous than those of *Yucca elata*. The survival of *Yucca elata* in the drifts hinges in part upon the production of adventitious roots at higher stem levels. *Yucca* plants 70 inches tall with dead upper portions, but living below, and covered with adventitious roots to the crown base, bend from their own weight when left unsupported by the drifts. One vertical branch produced 251 adventitious roots ranging in length from 51 inches below to 28 inches at higher stem levels (Fig. 18). That this root-bearing part of the main axis is stem rather than root is evidenced by the new leaf growth near the present sand surface. Another *Yucca* 104 inches in height and having 416 adventitious roots, exhibits new growth at the base and illustrates the tendency of these monocot stems to increase in diameter at higher levels (Fig. 19).

*Species prominent in some part of the White Sands.*—All shrubby species in the following list are marked by an asterisk.

## GYMNOSPERMS

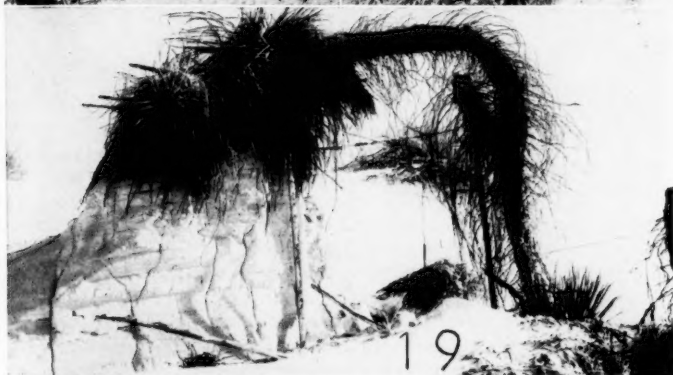
- \*1. *Ephedra torreyana* S.Wats.

## DICOTYLEDONS

- |   |  |
|---|--|
| 1. <i>Abronia angustifolia</i> Greene   | 23. <i>Helianthus annuus</i> L.                          |
| 2. <i>Andropogon carnosus</i> (Wooton) Brand  | 24. <i>Hymenopappus arenosus</i> Heller                  |
| 3. <i>Asclepias arenaria</i> Torr.  | 25. <i>Ipomea hirsutula</i> Jacq.                        |
| 4. <i>Aster cichoriaceus</i> (Greene) Blake   | *26. <i>Lycium berlandieri</i> Dunal var.                |
| 5. <i>A. parvula</i> Blake  | <i>parviflorum</i> (Gray) Terrac.                        |
| *6. <i>Atriplex canescens</i> Pursh   | *27. <i>L. torreyi</i> A.Gray                            |
| *7. <i>Baccharis glutinosa</i> Pers.  | 28. <i>Mentzelia integra</i> H.B.K.                      |
| 8. <i>Centaureum texense</i> (Griseb.) Fernald  | 29. <i>Oenothera albicaulis</i> Pursh                    |
| 9. <i>Cereus gonacanthus</i> Engelm. & Bigel.   | 30. <i>O. filifolia</i> (Eastw.) Tidestrom               |
| *10. <i>Chrysothamnus nauseosus</i> (Pall.) Britton. var. <i>latisquameus</i> (A.Gray) H. M. Hall | 31. <i>Phacelia corrugata</i> A.Nels.                    |
| *11. <i>C. pulchellus</i> (A.Gray) Greene   | *32. <i>Poliomintha incana</i> (Torr.) A.Gray            |
| *12. <i>Clappia suadifolia</i> A.Gray   | 33. <i>Populus wislizeni</i> (Wats.) Sarg.               |
| 13. <i>Coldenia hispidissima</i> (Torr.) A.Gray   | 34. <i>Psilostrophe tagetinae</i> (Nutt.) Greene         |
| 14. <i>Comandra pallida</i> A.DC.   | *35. <i>Rhus trilobata</i> Nutt.                         |
| 15. <i>Cryptantha fulvocanescens</i> (A.Gray) Payson  | ex Torr. & Gray  |
| 16. <i>Cucurbita foetidissima</i> H.B.K.  | 36. <i>Salsola kali</i> L. var. <i>tennifolia</i> Tausch |
| 17. <i>Dithyrea wislizeni</i> Engelm.   | 37. <i>Suaeda suffrutescens</i> S.Wats.                  |
| 18. <i>Frankenia jamesii</i> Torr.  | 38. <i>Selinocarpus chenopodioides</i> A.Gray            |
| 19. <i>Greggia camporum linearifolia</i> Jones  | 39. <i>Senecio spartioides</i> Torr. & Gray              |
| *20. <i>Gutierrezia sarothrae</i> (Pursh) Britt. & Rusby  | 40. <i>Sphaeralcea angustifolia</i> (Cav.) G.Don.        |
| *21. <i>Haplopappus heterophyllus</i> (A.Gray) Blake  | 41. <i>S. incana</i> Torr.                               |
| 22. <i>H. spinulosus</i> (Pursh) DC.  | 42. <i>Thelesperma megapotamicum</i> (Spreng.) Kuntze    |
|   | 43. <i>Tidestromia lanuginosa</i> (Nutt.) Standl.        |
|   | 44. <i>Verbesina encelioides</i> (Cav.) Benth.           |
|   | 45. <i>Zinnia grandiflora</i> Nutt.                      |

## MONOCOTYLEDONS

- |  |  |
|--|--|
| 1. <i>Andropogon scoparius</i> Michx.                      | 8. <i>Sporobolus airoides</i> Torr.      |
| 2. <i>Aristida adscensionis</i> L.                         | 9. <i>S. contractus</i> Hitchc.          |
| 3. <i>Bouteloua barbata</i> Lag.                           | 10. <i>S. flexuosus</i> (Thurb.) Rydb.   |
| 4. <i>B. breviseta</i> Vasey                               | 11. <i>S. giganteus</i> Nash             |
| 5. <i>Distichlis spicata</i> (L.) Greene                   | 12. <i>S. nealleyi</i> Vasey             |
| 6. <i>Muhlenbergia pungens</i><br>(Thurb.) Rydb.           | 13. <i>S. cryptandrus</i> (Torr.) A.Gray |
| 7. <i>Oryzopsis hymenoides</i><br>(Roem. & Schult.) Ricker | *14. <i>Yucca elata</i> Engelm.          |
|  | 15. <i>Juncus mexicanus</i> Willd.       |



Figs. 17-19.—17. Shallow lateral roots of *Yucca elata* exposed by wind action; 18. *Yucca elata* buried and subsequently exposed by migrating drift. 251 adventitious roots were counted along the lower half of the stem. Note new leaf growth at base and 1 meter from base; 19. *Yucca elata* stem exposed by wind action which bears 406 adventitious roots between the crown base and the new leaf growth at the sand surface (meter stick shown).





Fig. 20—Hardened gypsum stabilized by divergent stems and slender adventitious roots of a single tree (*Populus wislizeni*).

Comparison of this flora with that of quartz sand dunes.—The limited floral diversity in the White Sands, for even a dune region, is evident in the contrast between the total of less than 70 species in this area with the 316 different seed plants on a 1500-acre sand mound in Muscatine and Louisa Counties, Iowa (Brown and Brown, 1939), and with the 755 spermatophytes supported on a strip of the Lake Michigan dunes one mile wide and 10 miles long, this latter flora being given greater variety, however, by the vegetation in several small swampy areas between the dunes and by proximity to a railroad (Lyon, 1927). The lack of floral variety in the White Sands is associated in part with regional and in part with strictly local environmental peculiarities.

*Prosopis glandulosa* Torr. always appears in the loose, wind-blown phase of the more sandy soils of southern New Mexico (Campbell, 1929). While this species of *Prosopis* occurs where gypsum spills over on the desert plains adjacent to the White Sands, it does not survive in even the younger dunes or intervening flats. The plants associated with *Prosopis* in the quartz sand dunes of southern New Mexico include 4 species which also grow in the White Sands: *Yucca elata*, *Atriplex canescens*, *Sphaeralcea incana* and *Sporobolus cryptandrus*. In addition, the two dune areas have in common the genera *Muhlenbergia* and *Bouteloua*, and the same or different species of *Gutierrezia*, *Aster* and *Helianthus*. *Cucurbita foetidissima*, which is marginal in the White Sands, appears in the dunes in the southern part of the state when favorable moisture conditions continue for a time. *Atriplex*

*canescens*, one of the hummock formers in the gypsum drifts, grows also in the quartz sand dunes of the Salton Sea in California (Rempel, 1936), but *Larrea tridentata* or creosote bush, the most numerous of the perennials in these Salton drifts, does not appear in the New Mexico gypsum deposit or on the alkali flats adjacent on the southwest, although the Tularosa basin lies in the lower Sonoran life zone commonly designated as the creosote bush zone.

Two grass species common in the gypsum deposit, *Andropogon scoparius* and *Sporobolus cryptandrus*, are also a part of the typical flora of the Dunes State Park along Lake Michigan (Lyon, 1927) and of the sand mounds in Muscatine and Louisa counties, Iowa (Brown and Brown, 1938). The three areas also have in common different species of the genera *Aristida*, *Juncus*, *Populus*, *Comandra*, *Salsola*, *Rhus*, *Oenothera*, *Asclepias*, *Aster*, and *Helianthus*. The genera *Oryzopsis*, *Muhlenbergia*, *Atriplex* and *Senecio* occur both in the Lake Michigan dunes (Lyon, 1927) and in the White Sands.

Five species growing in the White Sands, *Frankenia jamesii*, *Andropogon carnosus*, *Greggia camporum linearifolia*, *Selinocarpus chenopodioides*, and *Bouteloua brevisetata* are considered specific indicators of gypsum (Wootton and Standley, 1915) and do not commonly occur in quartz sand deposits.

Among the younger dunes adjacent flats are often dominated by entirely different plant species. The occurrences of *Hymenopappus arenosus* and of *Comandra pallida* are highly localized, both being restricted to a few marginal flats, most of which also produce *Yucca elata*, *Populus wislizeni*, *Andropogon scoparius* and *Bouteloua brevisetata*.

Other species appear transiently since almost any kind of seed germinates readily in the moist calcium sulfate of the flats. Even watermelon seeds dropped on the hard-packed camp ground surface germinate and survive through the seedling stage. A *Cortadiera* spp., apparently introduced by chance, survived for three years on a small peripheral drift. Low moisture permits only a limited number of species to gain a foothold in the dunes through germination, but *Cucurbita foetidissima*, *Helianthus annuus*, *Oryzopsis hymenoides*, *Sphaeralcea incana*, *Thelesperma megapotamicum* and *Yucca elata* commonly become established in the drifts by this means at times of the year when moisture is relatively abundant.

*Other selective environmental factors.*—In addition to wind action on the dunes, at least four environmental factors in the area of the gypsum deposit tend to discourage growth of less resistant species and to contribute to the gross structural peculiarities in the surviving plant population. (a) Low atmospheric humidity, conducive to excessive transpiration, is associated with an average annual precipitation of slightly less than nine inches, 60% of which falls during the rainy season between June and the latter part of September (Schaffner, 1948). (b) The soil water is a saturated solution of calcium sulfate, which alone has an osmotic pressure amounting to only 0.26 to 0.3 atmospheres at 20°C. and which for that reason should not interfere with absorption. Kisser (1927) found, however, that water economy in *Triticum vulgare* seedlings grown in a single-salt nutrient is least favor-

able in calcium solution in spite of a well developed root system with abundant hairs. (c) Light intensity is excessive, direct sunshine from the usually cloudless sky being reflected brilliantly from the sand. These light conditions contribute to a wider temperature range between day and night than in the surrounding area. Also, the shallow water table and the low heat retentivity of the gypsum tend to depress night temperatures in the sands. (d) The formation of humus by the widely spaced plants is negligible, and the gypsum is deficient in at least three essential elements. The concentration of total nitrates and nitrites in sand from a flat in the immediate vicinity of roots where the vegetation is relatively abundant amounts to only 0.0008 per cent. Where nitrogen is limited this element is converted to protein in the root where it is absorbed (Turner, 1922). In the absence of nitrogen in upper plant parts most of the photosynthate is translocated basipetally, limiting growth in parts aboveground (Turner, 1922).

#### SUMMARY.

*Flora in general.*—Of approximately 70 plant species growing in gypsum dunes covering roughly 224 square miles, 11 dicotyledons and the one gymnosperm are shrubby, one dicotyledon (*Populus wislizeni*) attains tree-like proportions, and the monocotyledons include 13 grasses, one sedge, and *Yucca elata*, a shrub. This flora represents a large fraction of the vegetative climax on the desert plain adjacent on the northeast, subjected to the selective action of drifting gypsum, high light intensity, and deficiencies of nitrogen, potassium and phosphorus, which influences combine to eliminate approximately 28 species common in the surrounding country. Four species conspicuous in the gypsum sands are absent or occur sparsely in the adjacent area, and five others are gypsum indicators not commonly found in quartz sand deposits.

*Dune tolerance.*—*Rhus trilobata*, *Poliomintha incana*, *Atriplex canescens*, *Populus wislizeni*, and *Yucca elata* stabilize the substrate by adventitious roots, crowns of leaves, secondary root systems or closely grouped stems, retaining hardened, elevated gypsum pillars behind advancing drifts. *Ephedra torreyana* and *Chrysothamnus nauseosus* var. *latisquameus* stabilize small mounds in the outer interdunal depressions. That certain of these dune tolerant forms ordinarily originate in the flats and survive burial by elongating beyond the drifts is evidenced by *Yucca* stalks, covered by adventitious roots, standing in the wake of advancing dunes, by gnarled trunks of *Populus wislizeni*, also bearing adventitious roots, by the main axes of *Rhus trilobata*, *Poliomintha incana* and *Atriplex canescens* in the disintegrating hummocks, and by long stems of *Poliomintha incana* left prostrate on the sand surface following dune movement. *Comandra pallida* survives burial on dune faces by meristematic activity of an extensive rhizome system. *Oryzopsis hymenoides* and *Abronia angustifolia*, which appear farthest within the older interdunal depressions, do not survive burial, but propagate by seeds, as do a number of other annuals. At least six species commonly become temporarily established in the dunes by germination at times when moisture is relatively abundant.

*Root modifications.*—*Yucca elata* and *Populus wislizeni* produce the most conspicuous adventitious roots along buried stems, such roots in *Yucca elata* often numbering from 200 to 400 between the present sand surface and the crown base. Tap roots extend deeply into the substrate, and wind erosion exposes long, slender, shallow secondary root systems in shrubby species.

*Comparison with flora of other dune areas.*—Drift tolerant species common to the gypsum sands and quartz sand deposits include *Andropogon scoparius*, *Sporobolus cryptandrus*, *Atriplex canescens*, *Yucca elata* and *Sphaeralcea incana*. Different species of *Populus*, *Comandra*, *Rhus*, *Aristida*, *Oryzopsis*, *Oenothera* and certain other less prominent genera are common to the White Sands and several quartz dune areas.

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# The Taxonomy of *Halogeton glomeratus*

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In recent years an introduced poisonous range weed known botanically as *Halogeton glomeratus* (M. Bieb.) C. A. Mey., and commonly as halogeton, has caused much concern to livestock operators in the western United States, especially in the Intermountain Region. Losses of both cattle and sheep have been serious enough to warrant a complete investigation concerning the possibility of controlling this undesirable plant.

In the spring of 1950 a study of the life history, ecology, and control of the plant was begun by University of Idaho workers. During the course of the first two years research as complete a study as possible has been made of the taxonomic relationships and geographic distribution, particularly as indicated in the Old World literature. Other phases of the halogeton study are being prepared for publication elsewhere in the near future (Tisdale *et al.* 1952).

## ORIGIN AND TAXONOMIC CLASSIFICATION

*Halogeton glomeratus* was apparently first mentioned by Christen Friedrich Stephan in the late 18th or early 19th century. He called the plant *Salsola glomerata*. The name was never legally published so that it does not have any botanical standing. Marshal von Bieberstein described and legally published the plant as *Anabasis glomerata* in 1810, and reported that the plant grew in the remoter deserts of Siberia (Dayton, 1951).

Carl von Ledebour (1830), accompanied by his former students, Carl Anton Meyer and Alexander von Bunge, made a botanical exploration of the Altai region of Central Asia in 1826. The account of the trip was published in 1830.

On July 11, 1826 in the vicinity of Semipalatinsk, Carl Anton Meyer wrote, "The alkali spots, whose salt content was evident by the plants growing upon them were covered with *Polycnemum volvox*, (*Anabasis glomerata*), *Atriplex laciniatum*, *canum* n., *Statice gmelini*, *Camforosma ruthericum*, *Lepidium perfoliatum*, and *latifolium*, *Choridpora sibirica*, *Sisymbrium sophia*, *Iris halophila*, and *Glycyrrhiza glanulifera*."

Upon publication of the *Flora Altaica* (1830), which was based upon the collections made during this expedition, C. A. Meyer first proposed and published the generic name (*Halogeton*) as well as the specific name *glomeratus*.

Since the publication of the *Flora Altaica*, the genus has been treated in various ways by different botanists. Moquin-Tandon (1840) in a mono-

\* The data presented here were obtained during the course of a Special Research Project of the Forest, Wildlife and Range Experiment Station under the direction of Dr. E. W. Tisdale, Associate Professor and Head, Range Management, School of Forestry, University of Idaho. Acknowledgement is also extended to Drs. W. D. Billings and I. H. Robertson of the University of Nevada for reading the paper and making helpful suggestions regarding it.

graph of the *Chenopodiaceae*, arranged the family into two sub-orders: (1) embryo annular, (*Cycloclobeae*), and (2) embryo spirally coiled, (*Spirolobeae*). Under the latter he listed the tribe (*Salsoleae*), with the genus *Halogeton* in this category. The genus was divided into species having three-winged and five-winged sepals when in fruit, with *H. glomeratus* in the latter. Eleven species of *Halogeton* were described, one of which was listed as a species dubia.

Ledebour (1847-49) in his *Flora Rossica* retained essentially the same sub-order and tribe grouping as Moquin-Tandon. He did, however, change the arrangement of the genus *Halogeton*. The genus was divided into four sections: these being, *Noaea*, *Agathophora*, *Euhalogeton*, and *Halanthium*. Ten species under these sections were described, one as being a species dubia. Greater emphasis was placed on *Euhalogeton* since it was the only section completely described, the others being merely listed, giving the authority, species, and synonyms. *H. glomeratus*, *H. sativus*, and *H. monandrus* were grouped into this section. The close similarity of *H. glomeratus* and *H. sativus* was mentioned.

Volkens (1892) in a treatment of the *Chenopodiaceae* gave the four sections of Ledebour generic rank arranged in the following order:

*Spirolobeae-Salsoleae-Anabasinæ*

- a. *Anabasideae*  
*Noaea*  
*Anabasis*

- b. *Halimocnemideae*  
*Halanthium*  
*Agathophora*  
*Halogeton*

The same author stated that the genus comprised a small group of four to five species occurring in Spain, Morocco, and Central Asia, to Tibet and Mongolia. The genus was arranged in the following manner:

"Section I. *Euhalogeton* Volkens. Seed all vertical. *H. tibeticus* Bunge. *H. glomeratus* (M. Bieb.) C. A. Mey., in the Aral-Caspian region and the Songaria-Turkestan region. *H. sativus* L. In Spain and Algeria."

Section II. *Micropeplis*. Seed mostly horizontal. *H. arachnoides* Moq. In the Gobi desert.

The latest treatment of the *Chenopodiaceae* is that by Ulbrich (1934). The family arrangement into embryo annular, and embryo spirally coiled has been retained. *Halogeton* is classified under the sub-family (*Salsoloideae*), sub-tribe (*Salsoloideae-Salsoleae-Anabasinæ*), Section I, (*Salsoloideae-Salsolea-Anabasinæ-Halimocnemideae*). Section I, *Euhalogeton* Volkens, has been eliminated as has Section II, *Micropeplis*. The latter section was given generic rank. Three species are listed for *Halogeton* and Ulbrich stated that all three are much alike.

*Halogeton glomeratus* was first discovered in the United States in June 1934 by Mr. Ben Stahmann, then a Forest Service official, one mile northwest of Wells, Elko County, Nevada at 5,700 feet above sea level. He reported that the plant was common on disturbed areas (Dayton, 1951).

The first published record was made by Standley (1937) based on a collection made by Stahmann near Wells, Nevada in August 1935. This specimen was identified by Dr. Paul Aellen, authority on the group, as *Halogeton sativus*.

Macbride (1918) reported that *H. sativus* was a synonym of *H. souda*. Fosberg (1940) recorded *H. souda* as a shrub or suffrutescent herb, very close to *Salsola* and introduced into Elko County, Nevada from the Mediterranean region. Morton (1941) stated that the plant found in Elko County was not *H. souda* or *H. sativus* but *H. glomeratus*.

Holmgren (1942) in a flora of northeastern Nevada gave a brief description of the plant and stated that the weed was spreading rapidly and was then in western Utah. Davis (1952) in a flora of Idaho has included the genus and *H. glomeratus*. Other American floras to date do not list the genus or species.

A full treatment of the genus is needed but is not possible at the present time. However, an effort will be made in this paper to give a description as complete as limitations permit.

Various members of the family *Chenopodiaceae* have in the past been confused with *Halogeton*. This confusion has been mainly with the herbaceous species of the family. A key showing the different characteristics of each genus, excluding shrubs, is therefore included.

The key form and order of arrangement follows that of Abrams (1950). Minor descriptive changes have been made in the key as needed to clarify differences.

#### CHENOPODIACEAE

Embryo annular, semiannular, or conduplicate, surrounding the endosperm.

Leaves not reduced to scales; stems not jointed.

Leaves opposite; calyx-segments strongly imbricate ..... *Nitrophila*

Leaves alternate; calyx-segments slightly or not at all imbricate.

Fruit enclosed by the calyx.

Flowers perfect or polygamous, all similar.

Fruiting calyx wingless and spineless.

Stamens and calyx-segments usually 3-5.

Fruiting calyx herbaceous or fleshy ..... *Chenopodium*

Fruiting calyx dry and strongly reticulated; leaves pinnatifid ..... *Roubieva*

Stamens and sepals 1 ..... *Monolepis*

Fruiting calyx winged or armed with spines.

Calyx horizontally winged.

Annuals; leaves flat, toothed ..... *Cycloloma*

Woody perennials; leaves linear, terete.

(One species annual, leaves flat, linear) ..... *Kochia*

Calyx-lobes each armed with a hooked spine, leaves flat, linear pilose

..... *Bassia*

Leaves reduced, scale like; stems jointed; flowers in fleshy spikes or sunken in the joints of the stem.

Branches and flower-clusters alternate ..... *Allenrolfea*

Branches and flower-clusters opposite ..... *Salicornia*

Embryo spirally coiled; endosperm little or none.

Flowers perfect, leaves very spiny, alternate.

Fruiting calyx with a horizontal wing. Seed horizontal ..... *Salsola*

Flowers perfect or polygamous, leaves alternate, terete, or narrowly linear.

Fruiting calyx wingless, leaves not tipped with a hair-like bristle. Seed horizontal or vertical ..... *Suaeda*

Fruiting calyx five winged, the segments being free nearly to the base. Leaves tipped with a hair-like bristle. Seed vertical ..... *Halogeton*

The plants most likely to be confused with *Halogeton* are *Kochia*, *Bassia*,



*Salsola*, and *Suaeda*. *Kochia scoparia*, also an introduced annual, differs from *Halogeton* by its flat, narrowly linear leaves. The perennial species of *Kochia* which occupy the same habitat as *Halogeton* are distinguishable by being half shrubs, and not having the hair-like bristle at the apex of the leaves. The calyx does not have the prominent five wings at maturity as in *Halogeton*. The stems and leaves of *Kochia* also have a white tomentose covering which *Halogeton* does not. *Bassia* differs from *Halogeton* in having stiff whitish stems, with the leaves flat, tomentose, oblong-linear, and acute. At maturity the calyx lobes each have an elongated spinescent tip. In contrast *Halogeton* has mainly purple stems, the leaves are terete, fleshy and setaceous.

*Suaeda* is most easily distinguished from *Halogeton* by the absence of the hair-like bristle at the tips of the leaves. While the seed of *Suaeda* may be either horizontal or vertical, the calyx is wingless in contrast to the five winged calyx of *Halogeton*. The seed of *Suaeda* is black and shiny, while that of *Halogeton* is black, with a rough non-shiny seed coat.

Ulrich (1934) gives the following description and species for the genus *Halogeton*.

"*Halogeton* C. A. Mey., in Ledeb. Fl. Alt. I. (1829).

(*Agathophora* Bunge. in Mem. Acad. St. Petersb. 7. ser. IV. Nr. 11 (1862), ex. p.; *Halogeton* Sect. I. *Euhalogeton* Volkens in E. P., I Aufl., III la. (1893); *Halogiton* Gurke. in Richter-Gurke, Pl. Europ. II (1899).

Flowers polygamous in small flowered glomerules with two bracteoles. Flowers axillary, apetalous, sepals five, one nerved nearly free to the bottom, mostly winged. Stamens 5 or less, inserted in the receptacle, top part of anthers blunt, 4-5 papilla at bottom of filaments. Ovary ovate, style short, stigmas 2, filiform. Glandular lobes of the receptacle alternate with the stamens, these lacking on the female flowers. Seed vertical, almost circular, integument simple, membranaceous, endosperm none. Embryo spirally coiled, radicle dorsal. Leaves alternate, sessile, terete, succulent, having a thread-like bristle at the apex. Annuals, glabrous, or finely pubescent.

Name from the Greek word meaning "salt neighbor or inhabitant." Type species: (*Halogeton glomeratus*) (M. Bieb.) C. A. Mey. (1829).

A small genus containing but three species; found mainly in the western steppe areas of Central Asia, on moist saline soil.

1. *H. tibeticus* Bunge. (*H. glomeratus*, Herb. of Hook. f. et. Thomas.). Found in the highlands of western Tibet. Very little difference is evident between this and the following species.

2. *H. glomeratus* (M. Bieb.) C. A. Mey. (*Anabasis glomerata*, M. Bieb. (1810), *Salsola glomerata* Steph. ex Bunge.; *Salsola obtusifolia* Hort. Bercl.). Found in the salt steppe of south Russia from the Ural and Aral-Caspian region up to the Kirgiz and Songarian area and also in the deserts of Tibet.

3. *H. sativus* (L.) C. A. Mey. (*Salsola sativa* L. (1762); *Salsola souda* Loebl. (1758); *Suaeda setigera* Webb.; *Halogeton souda* (Loebl.) Macbride (1918). Occurs in southern Spain and North Africa."

The original description of *H. glomeratus* as translated from the *Flora*

*Altaica*, Vol. I, is as follows: (See also figures 1, and 2). "*Halogeton glomeratus* C. A. Mey., (1829).

Annual, the many branched leaves alternate, fleshy, cylindrical, with a hair-like bristle at the apex, glomerules dichotomous, sessile, flowers with 5 sepals, 3 anthers, eventually becoming five winged at maturity. Type locality: In the vicinity of Semipalatinsk by C. A. Meyer. Habitat: In the western deserts of Songaria, and Kirgiz; frequently on dry, saline, clay spots. Flowers in July and August; seed mature in September.

Annual, glabrous, glaucous. One main root, slender; with several stems branching from this. Stems often purple colored, erect or ascending, 1-30 inches high. Stems mostly diametrically opposite, many branched, branches alternate. Leaves fleshy, cylindrical, club shaped, blunt, having a capillary seta or hair at the apex, somewhat hairy at the base, semi-stem clasping, alternate, the lowest sometimes opposite. Glomerules small, dichotomous in clusters, axillary, sessile, having many leaves, flowers 5, 7-9 in one cluster. Flowers very small, hermaphroditic, sessile in the dichotomous flower clusters and in the axils of the many leaves, some bibracteolate; the rest located in the same fashion but without bracteoles. The bracts or sepals of the two flowers are similar but the latter not conspicuously winged at maturity, having the sepals tightly enclosing the utricle at maturity, coriaceous, tips with tooth-like appendages or short erect wings. Sepals 5, rigid, oblong, becoming yellow, the summit hyaline, rather blunt at end; wings equal, disk shaped, rounded, broad, membranous, often red tinged, spreading at maturity. Stamens 1-3 rarely 5, inserted in the receptacle; one often sterile. Anthers yellow, attached by the middle, style semi-bifid, short, slender, stigmas 2, filiform and hairy at the base. Seed vertical, no endosperm, integument membranous, embryo spirally coiled. Radicle dorsal."

Muschler (1912) in his *Flora of Egypt* lists *H. sativus* as occurring in the Tel-el-Kebir region of that country. This area is a plateau located on the eastern edge of the Libyan desert and in the southwest corner of Egypt. He also states that the species is known from Spain, Algeria, West and Central Asia. To show the similarity between this species and *H. glomeratus* his description is included. The difference between the two species are underlined.

"*Halogeton sativus* (L) C. A. Mey.

Herbaceous, glabrous, 15-30 cm. high, branching from the base, branches erect, or ascendant, bullate-papillous. Leaves 2-8 mm. long, patulous, or deflexed, alternate, terete, oblong, linear, *produced into a spine*, succulent, farinoso glaucous. In the axils solitary or sometimes clustered, *wing patulus erect*, obovate, rotundate, fimbriate, striate, often rose purple colored."

This species is commonly known in Spain and North Africa as *barilla fina* or *barilla*. Ulbrich (1934) states that at one time *barilla fina* was grown occasionally as a vegetable plant, and also as a source of soda in the Mediterranean region. He quotes a publication by Juabert da Passa (1779) to the effect that *barilla fina*, and a less desirable variety known as *al gazul* were used. With the development of barley culture, *barilla* production was discontinued.

Bedevain (1935) gave the following common names for *H. sativus*: Arabic, quraynah; English, cultivated saltwort; French, haloget, barilla; Spanish, barilla fina; German, zahmes salzkraut; Turkish, kaly otu. No common name for *H. glomeratus* has been found in the European literature.

The *Index Kewensis* lists 26 plants which have at one time or another been placed in the genus *Halogeton*. Many of these are synonyms and are listed as such. Synonyms given by Ulbrich (1934) eliminate a few more species. As well as can be ascertained at the present time, there are apparently three confirmed species and four more which may belong to the genus. The latter species and the country of occurrence as reported in the *Index Kewensis* are as follows:

*H. acutifolius* Bunge. 1847, Siberia.

*H. articulatus* Ball. 1878, Spain, Morocco, Egypt.

*H. malacophyllus* Bunge. 1847, Turkestan.

*H. tournefortii* Faub. and Spach. Persia.

#### GEOGRAPHIC DISTRIBUTION

A number of specimens of *Halogeton* secured on loan from the United States National Herbarium through the courtesy of Dr. A. C. Smith, Curator, Division of Phanerogams, have been examined. The specimens have been compared with plants collected in southern Idaho and unless otherwise stated have been found to be *H. glomeratus*.

1. *H. glomeratus*, US. No. 1605952, Lamaryuru, Ladakh, Kashmir, by Walter Koelz No. 2725, August 29, 1931. Growing along stream bank, altitude 9,500 feet.

The utricle without the bracteoles and tightly enclosed by tipped coriaceous sepals is mature on this specimen; the bibracteolate utricle having widely spreading five-winged sepals is not (See Fig. 2).

2. *H. glomeratus*, US. No. 1609138, Pituk, Ladakh, Kashmir, by Walter Koelz, No. 6313, August 4, 1933.

Pituk is about seventy miles east of Lamaryuru. This specimen is mature and in seed.

3. *H. glomeratus*, US. No. 1609182, Pituk, Ladakh, Kashmir, by Walter Koelz, No. 6312, August 4, 1933.

This specimen is not mature and in seed, yet was collected on the same date and at the same locality as the mature specimen No. 1609183 listed above. The characteristics fit the description given for *Halogeton* but the specimen differs from typical *H. glomeratus* by having long, dense, fine branches leading from the main stem. While the leaves have the hair-like bristle at the apex, they are much smaller and have more pubescence at the base. This specimen may possibly be *H. tibeticus*.

4. *H. glomeratus*, US No. 66269, Persia Al de Bunge. Collected 18 ?  
No specific date or locality given on specimen.

5. *H. glomeratus*, US. No. 66270, Songaria, Tarbagatai, by Shrenk 18 ?  
No specific date or locality given on specimen.

6. *H. sativus*, US. No. 550617, Biskra, Algeria by L. Chevallier, No. 505, October 9-31, 1902. Growing in humid depressions along stream banks and on the margins of the town.

This specimen is mature and in seed and checks perfectly for *H. glomeratus* but not for *H. sativus*.

7. *H. sativus*, US. No. 133968, El Aghouas, Boreal Africa, by E. F. Pasis.

This specimen checks with the available description of *H. sativus* by



Fig. 1. *Halogeton glomeratus* at various stages of growth.—a. Seedling stage in May; b. Plant on June 15, 1951. Note diametrically opposite stems. Small plant at lower right is *Salsola kale* var. *tenuifolia*; c. Plant at maturity. Note mass of light tan colored sepals along stems. Plant in right background is a mature *Salsola kali* var. *tenuifolia*.

Muschler (1912). The leaves are produced into a more pronounced and distinct spine, which is 3-4 mm. long. The wing patuls or calyx segments are erect, not having the summit hyaline and being much smaller than those of *H. glomeratus*.

#### NATIVE HABITAT

As can be noted from both the literature and specimens cited, *H. glomeratus* is widely distributed in the Old World, apparently in a variety of habitats, but restricted to arid and semi-arid areas.

C. A. Meyer (1830) gave the habitat as dry saline clay spots and the distribution as being the western deserts of Songaria to Kirgiz. Kirgiz is now known as Kazakh S.S.R., and several other small republics of the U.S.S.R. are in the same area. Songaria is now known as Dzungaria and is located in northwest China.

Ulbrich (1934) gave the habitat as "salt spots" and the distribution of from the Ural and Aral-Caspian region up to the Kirgiz and Dzungaria area and in the deserts of Tibet. Both habitat references correspond to the Russian definition of solonetz and solonchak edaphic areas which could also be defined as saline and alkali spots.

The areas mentioned by Meyer and Ulbrich have been classified by Berg (1950) as steppe, semi-desert and desert. That author states that on the basis of vegetation, the steppe may be called a grassland. Dominant steppe grasses are *Festuca sulcata*, *Stipa* sp., *Koeleria gracilis*, and *Agropyron cristatum*. Within this grassland occurs small edaphic areas consisting of solonchak and solonetz spots. The vegetation of the latter saline spots is *Glycyrrhiza uralensis*, *Agropyron ramosum*, *Kochia prostrata*, and *Statice gmelini*.

Within the semi-desert most of the vegetation is dominated by *Artemisia*. The northern zone is of an *Artemisia*-grass type with grasses predominating. In the southern part of the region, grasses are gradually replaced by several genera of the *Chenopodiaceae*; of these the genus *Atriplex* is best represented. Species found on solonetz soils are, *Artemisia pauciflora*, *Camphorasma monspiciaca*, *Atriplex canum*, *Kochia prostrata*, *Cercocarpus arenarius*, *Ferula caspia*, *Statice gmelini*, and *Anabasis salsa*. This description by Berg as well as some of the species given is similar to the account for the habitat of *H. glomeratus* by C. A. Meyer (1830) presented on page 1 of this paper.

#### LIFE HISTORY AND OCCURRENCE IN THE UNITED STATES

In addition to the state of Nevada, halogeton now occurs in Utah, Idaho, Wyoming, Montana, Colorado, and California.

In southern Idaho, halogeton is found at elevations of from 4,200 to 6,500 feet above sea level, being most abundant at the lower elevations in the salt desert shrub vegetation type, on solonchak and grey desert soils. In the Raft River Valley, Cassia County, Idaho, halogeton will germinate in the field as early as February. Much of the seed germinates in the month of March, and summer germination will also occur if sufficient precipitation is received.

Plants germinating in March made very little top growth until the hot summer months of June and July when most vigorous top growth took place.

Late summer germinating plants often assumed a single stemmed growth habit. All summer germinating plants which survived showed marked ability to complete the life cycle in a shorter growing period. The plants normally begin to flower during the first part of July. Being apetalous, halogeton does not produce showy blossoms. The showy five-winged sepals enclosing the fruit developed during the first part of September. All plants matured by mid-September and seed was dispersed in October and November. Total height reached varied with site quality, and mature plants were from 1 to 30 inches in height.

Three forms of plant distinguished on the basis of color have been found in the Raft River Valley. The normal form has leaves which are bluish-green in color and are covered with a fine grey coating. Another form is similar in structure but has leaves which are dark green in color and not covered with the fine coating. The sepals of this form are reddish in the

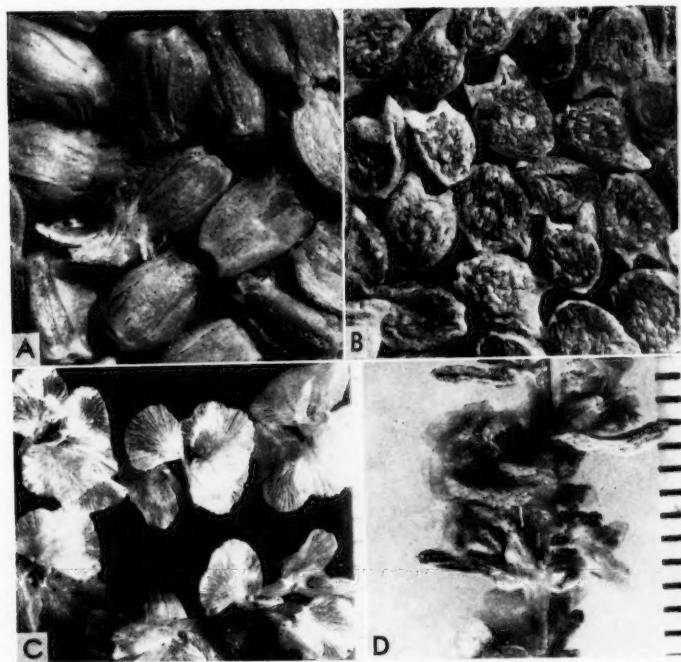


Fig. 2. Forms of fruit found on the same mature plant of *Halogeton glomeratus*.— a. Brown form with persistent, coriaceous sepals. 20×; b. Black form without outer covering of five-winged sepals. 15×; c. Five-winged sepals enclosing black form of seed. 4×; d. Position of two forms of fruit on a halogeton stem: brown form: five-winged sepals enclosing black form.

fall in contrast to the normal form which has light tan colored sepals. Still another form which is scarcely distinguishable from the normal form during the summer months was found. Close examination reveals it to be lighter green in color, rather than bluish-green. In the fall, this light green form turns purplish in color, and does not have the mass of light tan sepals along the stems which the normal form possesses. The purple form also produces an abundance of seed which is enclosed by coriaceous sepals with tooth-like appendages or short erect wings. Some of the normal form of seed enclosed in five-winged sepals is also produced. All forms of plant are found growing side by side in a halogeton stand, however, the anomalous plants are not as abundant.

Observations made during the course of these studies indicate that halogeton has apparently found a permanent place in the flora of the Intermountain Region and is rapidly fitting into an environment comparable to that described for its native habitat.

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## A Revision of the Choanephoraceae

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It was the writer's good fortune to isolate the fungus *Choanephora cucurbitarum* (Berk. and Rav.) Thaxter upon several occasions in Wisconsin. In addition to this material, a culture of *Blakeslea* from the Centraalbureau voor Schimmelcultures was obtained through the courtesy of Dr. David Perlman. In studying these isolates of *Choanephora* and *Blakeslea* it was found that no taxonomic treatment was entirely satisfactory and, in fact, the only modern attempts at treatment of the order Mucorales were those of Zycha (1935) and Naumov (1939). It seemed, therefore, worth while to summarize the observations made upon the members of this family and to provide a treatment of the family, which is composed of species characterized by growth upon higher plants.

As interpreted here the Choanephoraceae contain only two genera, *Choanephora* and *Blakeslea*. The first of these produces sporangia and conidia asexually; the latter forms sporangia and sporangiola. The two genera considered as making up the family have so many similarities that all workers have placed them adjacent to one another in the various systems of classification. Each grows typically upon higher plants; each has zygosporangia that are more like those of *Syncephalis* than like those of *Mucor*; the sporangia are similar in both; the conidia in *Choanephora* are reminiscent of the sporangiola in *Blakeslea*; both have a tendency to die in culture in a relatively short time and to produce a similar appearing aerial mycelium.

The writer's definition of the family is in agreement with that of Naumov (1939), who excluded *Cunninghamella* because this genus had zygosporangia formed in a *Mucor*-like manner and produced light-colored conidia. Fitzpatrick (1930) included the genus *Cunninghamella* within the family Choanephoraceae.

CHOANEPHORACEAE Fitzpatrick, Lower Fungi 258. 1930, emend. Naumov,  
Clés des Mucorinées, 97. 1939.

Mycelium hyaline, much-branched, rapid-growing; sporangiola, conidia and sporangia always upon separate stalks; conidiophores divided, bearing dark-colored conidia that are often striate; sporangiophores bearing sporangia or sporangiola with persistent walls; sporangia many-spored, columellate, often borne circinately; sporangiospores usually with bristle-like structures at each end, brown-colored, often striate; zygosporangia smooth or nearly so, borne between two closely appressed suspensors; typically inhabiting higher plants.

BLAKESLEA Thaxter, Bot. Gaz. 58: 353. 1914.

Aerial mycelium cottony, abundant, rapid-growing, producing two types of sporangiophores; sporangiophores bearing sporangia or sporangiola but never both upon the same sporangiophore; sporangia with columellae on unbranched sporangiophores; sporangiola

without columellae, borne on small vesicular sterigmata which are in turn attached to sporangioliferous heads; sporangioliferous heads at the ends of branches which are produced at the tip of the sporangiophores; sporangiospores from both types of sporangia striate, dark, with appendicular processes; zygospores formed between equal suspensors.

A monotypic genus found in the tropics or semi-tropics. *Blakeslea* is a genus closely related to *Choanephora* but differs from the latter in that it produces sporangia instead of conidia. Both genera show the same type of gross cultural appearance, the same dark-colored appendaged sporangiospores, and the same type of zygospores. The conidiophores in *Choanephora* and the sporangiophores bearing the sporangia in *Blakeslea* are characteristically alike by being branched above and by producing at the ends of these branches a capitate enlargement upon which the conidia and sporangia respectively are borne. In his treatment of *Blakeslea* Thaxter pointed out that there are sporangia produced in *Blakeslea* and that *Choanephora* had homologous structures in the conidia which it produced. He interpreted the conidia of *Choanephora* as being one-spored sporangia. However, Thaxter was unable to remove the sporangial wall from the conidia of *Choanephora*. With the additional evidence of the similarity of the form of the zygospores the writer believes that Thaxter's theory may be correct.

BLAKESLEA TRISPORA Thaxter, Bot. Gaz. 58: 353.

Pls. 26, 27, and figs. 1-18. 1914.

1923. *Choanephora dichotoma* Gandrup, Besoek. Proefstat. Medel. 3:5 (Nomen nudum according to Weber and Wolf). 1940. *Choanephora trispora* (Thaxter) Sinha, Proc. Indian Acad. Sci. B. 11: 167.

Mycelium woolly, to 0.5 cm. high; cultures upon PDA<sup>1</sup> showing a honey yellow (Ridg.<sup>2</sup>) color both above and below, younger regions nearly white; odor slight; growth much like that of *Choanephora*; hyphae granular, to 10 $\mu$  in diam., showing here and there tight twisted knots of mycelium; sporangiophores short, apparently arising from aerial mycelium, non-septate, with a diam. of 10 $\mu$ , readily collapsing, not branched on the sporangiophores bearing true sporangia; true sporangia borne on straight or circinate sporangiophores; large sporangia spherical or slightly flattened, 25-72 $\mu$  in diam., at first yellowish, then brown; sporangial wall roughened but at maturity nearly smooth, hyaline, breaking open at the top to give two halves as in *Choanephora*; columellae elongate, oval to pyriform, with a very small collar, varying in diameter, usually 20-45 $\mu$ ; sporangioliferous sporangiophores branched above, branches ending in heads 35-45 $\mu$  in diam., these heads with sporangia attached by means of small spherical vesicle-like sterigmata; sporangia oval, 12-14 x 11-12.5 $\mu$ , with no columella, containing typically 3 spores but often more; sporangial wall hyaline; sporangiospores from sporangia and sporangia nearly equal, reddish brown, oval, striate, with appendages resembling bristles arising from a papilla at each end of the sporangiospore, appendages sometimes over twice the length of sporangiospore, sporangiospores 8-14.5 x 4.3-8 $\mu$ ; chlamydospores present; zygospores formed as in *Choanephora*, measuring 38-61 x 45-63 $\mu$ , spherical to slightly flattened, containing a large central globule; exospore thick, dark brown, not conspicuously roughened. (Zygospore description from Weber and Wolf (1927).)

Originally this species was found as a contaminating organism in a culture of *Botrytis rileyi* obtained from infected larvae which were found upon cow-

<sup>1</sup> Potato dextrose agar.

<sup>2</sup> Ridgway's Color Standards and Color Nomenclature (1912).

peas at Gainesville, Florida (Thaxter, 1914); later it was isolated from cucumber leaves (Weber and Wolf, 1927), *Sida acuta* (Weber and Wolf, 1927), associated with a mustiness of freshly picked tobacco leaves (Gandrup, 1923), said to be extremely common on faded leaves of tobacco in Sumatra and Java (Jochems, 1927), and as a secondary infection of leaves of *Colocasia antiquorum* (Sinha, 1940).

This species was not seen in Wisconsin, but a type culture from Baarn was studied and is the basis for the description given above. This organism was studied upon PDA rather than on CSM<sup>3</sup> since the latter medium apparently allowed inadequate growth although some fruiting did occur. Upon CSM a great amount of yellow pigment was formed. Soil extract agar was very unfavorable, producing little growth and no fruiting. Even using the more favorable PDA, growth seemed to be unhealthy at times, cultures now and then showing areas with the mycelium collapsing and appearing moist. On PDA sporangia were formed fairly readily but sporangia were found only after repeated examination of a number of cultures. When these sporangia were seen they developed to maturity in a day. To obtain suitable microscopic preparations one should make mounts when the heads have passed from the light-colored stage to a light brown but before they have taken on a metallic black, for at this stage the sporangia are shattered from the heads and in many cases have lost their sporangiospores.

In his treatment of the genus, Zycha (1935) had a synonym of *Blakeslea trispora*, *Choanephora persicaria* Eddy. In the species described by Eddy no conidia or sporangia were found. Consequently, it does not seem to be a synonym of *Blakeslea trispora* and had best be left as it is until additional information is obtained concerning it. The writer has observed that in the strain of *B. trispora* which he studied, sporangia were found only after considerable search. It seems very probable that some strains might exist in which the ability to form sporangia has been completely lost. If such were the case, *Choanephora persicaria* might be such a form.

According to Weber and Wolf (1927) the name, *Choanephora dichotoma* Gandrup, is a *nomen nudum*. They state that in correspondence with the Director of the Experimental Station at Deli, Medan, they learned that no technical description was ever drawn up and that this fungus, which had been found on musty, freshly picked tobacco leaves in Sumatra, later proved to be *B. trispora*.

Sinha (1940) stated that he had seen monosporous sporangia in *B. trispora* and consequently transferred the species to *Choanephora*.

Weber and Wolf (1927) made isolations of *B. trispora* from cucumber leaves. In mating some of these isolates that they obtained they demonstrated zygospores, indicating that the fungus is heterothallic.

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<sup>3</sup> Cutter's synthetic medium (Cutter, 1946) which is routinely used for the study of Mucorales is prepared as follows: dextrose 40.0 gm, KH<sub>2</sub>PO<sub>4</sub> 0.5 gm, asparagine 0.5 gm, MgSO<sub>4</sub> 0.5 gm, thiamin trace, agar 15.0 gm, distilled water 1000.0 ml.

CHOANEPHORA Currey, Jour. Linn. Soc. Bot. 13: 578. 1873.

1873. *Cunninghamia* Currey, Jour. Linn. Soc. Bot. 13: 334. 1904. *Choanephorella* Vuillemin, Bull. Soc. Mycol. Fr. 20: 28. (Nomen nudum.)

Sporangia on unbranched sporangiophores, with a columella; sporangiospores usually with hair-like appendages, striate or non-striate; conidiophores with a primary vesicle with secondary vesicles upon which the conidia are usually borne; conidia smooth or striate, without appendages; zygospores smooth, formed between tong-like twisted suspensors.

The species of *Choanephora* differ from *Blakeslea trispora* by the absence of sporangioli which are replaced by conidia. In one species of the genus, however, the conidia were not reported. The conidia are sometimes striate, sometimes smooth. The conidia are borne upon a primary vesicle or upon secondary vesicles borne on stalks from the main vesicle. In a few cases conidia are found upon the primary vesicle but always accompanied by other conidiophores which have conidia on secondary vesicles. The sporangiospores of *Choanephora* are either striate or non-striate and with but one exception possess hyaline hair-like appendages. All the known species of *Choanephora* in which zygospores have been found have proved to be heterothallic and the suspensors are equal and tong-like in shape. Typically, the zygospore walls are smooth or nearly so. The zygospores are said to contain commonly one large oil droplet at maturity.

All the species known appear to be weakly parasitic on flowers, fruits, and leaves of higher plants. The type species, *C. infundibulifera*, was first seen on *Hibiscus*.

Currey (1873) erected the genus *Cunninghamia* but shortly afterwards discovered that he had been in error since a genus in the conifers had already been given this name. He corrected himself in the same issue of the *Journal of the Linnean Society* by writing a note saying he was changing to *Choanephora cunninghamiana* the name *Cunninghamia infundibulifera* which he had previously proposed.

Vuillemin (1904) proposed the genus *Choanephorella* for the fungus, *Rhopalomyces cucurbitarum*, but he failed to give a description or a figure of it and he made no reference to where the species *R. cucurbitarum* had been published nor did he indicate who had erected it, therefore, it can be considered a *nomen nudum*. One assumes that this species of *Rhopalomyces* was the one erected by Berkeley and Ravenel (1875), if so, then it is a synonym of *Choanephora cucurbitarum*.

The following key is given for the species of *Choanephora*:

- |  |                           |
|--|---------------------------|
| 1. Sporangia present; conidia not known .....                          | <i>C. persicaria</i>      |
| 1. Sporangia and conidia both present .....                            | 2                         |
| 2. Secondary vesicles not persisting as funnel-shaped structures ..... | 4. <i>C. cucurbitarum</i> |
| 2. Secondary vesicles persisting as funnel-shaped structures .....     | 3                         |
| 3. Sporangiospores without appendages .....                            | <i>C. infundibulifera</i> |
| 3. Sporangiospores with appendages .....                               | <i>C. conjuncta</i>       |

# 1. CHOANEPHORA PERSICARIA Eddy, Phytopath. 15: 610.

Fig. 1. 1925.

Mycelial growth low, 2.5-12 mm. high; sporangiophores unbranched, arising directly from the mycelium, outer surface conspicuously roughened in upper half of their length and distinctly swollen, 0.5-2 mm. high; sporangia spherical, 64-128 $\mu$  in diam., average

100 $\mu$ ; sporangial wall covered with fine crystals, dehiscent, leaving a narrow collar at the base of the columella; columellae elongated, constricted at the base, pyriform to globose, hyaline, 76-121.5 x 49-83.6 $\mu$ ; sporangiospores oval or elliptical, elongated, often irregular in shape, longitudinally striate, hyaline or very slightly darkened, 19-22 x 11-15 $\mu$ , with fine radiating appendages in groups at either pole, these equal to the length of the spores or greater; conidia and sporangia not observed; chlamydospores cylindrical, hyaline, 15-26.6 x 11-16 $\mu$ , variable in shape and size, not numerous; zygospores unknown. (Description from Eddy.)

Isolated from decayed peaches from the New York market.

This species differs from the other species of *Choaneophora* in that no conidia were ever found and from *Blakeslea* in that no sporangia were ever seen. According to Eddy, Thaxter mentioned a species, which he did not name, and which is probably identical with *C. persicaria*.

It seems best to the writer to maintain this species until more information is available, although it may prove to be only a form of *C. cucurbitarum* which has lost its ability to form conidia or requires special conditions to produce them. Zycha (1935), on the other hand, treated this species as a synonym of *Blakeslea trispora*.

## 2. CHOANEOPHORA CUCURBITARUM (Berk. and Rav.) Thaxter, *Rhodora* 5: 102. Pl. 46, figs. 1-6. 1903.

1875. *Rhopalomyces cucurbitarum* Berkeley and Ravenel, *Grevillea* 3: 109. 1893. *Rhopalomyces elegans* Corda var. *cucurbitarum* Marchal, *Rev. Mycol.* 15: 11. 1901. *Choaneophora americana* Moeller, *Phycomyceten und Ascomyceten* 393. 1915. *Cunninghamella mandshurica* Saito and Naganishi, *Bot. Mag. Tokyo* 29: 285. 1934. *Choaneophora manshurica* (Saito and Naganishi) Tai, *Sinensia* 4: 219. (Fide Zycha)

Colonies white to a dirty grayish white, showing sporulation in concentric zones, later producing sterile mycelium; odor sweetish, resembling that of tomato leaves; sporangiospores arising from surface hyphae, unbranched, gradually enlarging above, often bent or circinate below the sporangium, hyaline, becoming darkened above, with a maximum diam. of 30 $\mu$ ; sporangia spherical to slightly flattened in the larger ones, at first white, later black, measuring up to 156 $\mu$ , more often 120 $\mu$ , containing from few to many sporangiospores; sporangial wall persistent, colored, breaking from above to base to give two equal halves; columellae pyriform to globose, with a small collar, up to 120 x 108 $\mu$ , usually smaller; sporangiospores not striate, light-colored, then brown, often granular, with hyaline hair-like bristles 1 to 1.5 times as long as the sporangiospores, ovoid to ellipsoid to almost triangular, 18-27 x 9-12.6 $\mu$ , averaging 22.2 x 10.8 $\mu$ ; conidiophores up to 30 $\mu$  in diam., ending in a primary vesicle from which secondary vesicles are produced on short stalks, secondary vesicles bearing conidia; conidia brown, ovoid, longitudinally striate, with a papilla at one end, slightly smaller than sporangiospores, 15-18 x 9-11.5 $\mu$ ; submerged mycelium with thickened, granular regions; chlamydospores in some strains, globose to oblong ellipsoid, sometimes in chains; zygospores formed between equal suspensors, at maturity dark brown, 50-90 $\mu$ , containing a large oil globule; zygospore walls smooth. (Chlamydospores and zygospores not seen, their descriptions taken from Wolf (1917).)

Isolated repeatedly from flowers and fruits of *Cucurbita Pepo* in the late summer and fall of 1946, Madison, Wisconsin; from flowers and fruits of the acorn squash, Pearl River, New York in the fall of 1948 and 1949. Found by Wolf (1917) upon flowers and fruit of squash in North Carolina, by Thaxter (1903) upon the flowers and fruit of pumpkin from Massachusetts, Florida, and elsewhere. Reported by Lefebvre and Weimer upon cowpeas in Georgia (1939) and by Sinha (1940) as a secondary invader of *Colocasia antiquorum*.

This fungus was found growing upon the blossoms of a pie pumpkin in the community gardens west of the Forest Products Laboratory at Madison,

Wisconsin. The summer had been a dry one, and the initial infections apparently occurred shortly after the first fall rains. The fungus was first noted upon a pumpkin fruit which was still young enough to have the flower attached. The fruit was about 2 inches in diameter, yellow in color, with signs of decay at the tip just below the blossom. The petals above this fruit were still firmly attached and apparently infected. This fruit was collected and brought into the laboratory. Within 24 hours after it had been placed in a moist chamber there appeared a great amount of white mycelium just below the flower and from the discolored areas which had been noted the day before. Two days after the material had been brought into the laboratory fruiting had begun. On a return visit to the garden it was found possible to pick up wilted and faded flowers which showed mycelium inside the collapsed flowers as well as occasionally mycelium and spore-bearing hyphae on the outside. From this time on until frost had killed the host, infected material could be obtained. The only infected parts were flowers and fruits up to the size of 2 or 3 inches in diameter. The infected fruits were characterized by being yellow with brownish colored spots located toward the flower end. Later these fruits would blacken and rot, with the tissue becoming soft and watery.

Fruiting could readily be obtained by slicing pieces of raw pumpkin, placing the pieces in Petri dishes, and inoculating them with conidia. Next, pure cultures were made by picking spores from a single sporangium. When the fungus was grown on soil extract agar very sparse growth with slight sporangial fruiting was obtained. On PDA growth was very good but fruiting was restricted typically to concentric zones; shortly afterwards the surface of the culture was overgrown by a felt of white mycelium which in some instances nearly reached the lid of the Petri dish. When the fungus was grown upon CSM both sporangia and conidia were present in abundance in the first 48 hours, followed then by an overgrowth of sterile mycelium. Fruiting appears to be best on malt agar.

It is of interest to note that observations on the above-mentioned pumpkin plants during the fall showed a great many insects present in the flowers, which tends to substantiate the observation made by Wolf (1917) that insects carry the spores of the fungus from one flower to another.

The writer believes this to be the first report of *Choanephora* in Wisconsin. The fungus has usually been reported from the south, although Thaxter found it in Massachusetts and had seen specimens collected in New York by Professor Peck and also material from Ohio from Professor Morgan.

Berkeley and Ravenel described the fungus first under the name of *Rhopalomyces cucurbitarum*. Their description was based upon a study of material which had been collected from decaying squash in South Carolina by Ravenel. The second synonym listed above, *R. elegans* var. *cucurbitarum* Marchal, was erected through a mistake on the part of Marchal who took Thaxter's earlier suggestion that *Choanephora cucurbitarum* might be a form of *R. elegans*. Therefore, Marchal made it a variety of *R. elegans*. The name *C. americana* Moeller was based upon material on *Hibiscus* from Brazil. Thaxter sent material of his species, *C. cucurbitarum*, to Moeller who found

the two species to be identical. Another name which Thaxter mentioned was the species *Aspergillus cucurbitaceus* Curtis which is in the Curtis Herbarium at Harvard, being represented by a herbarium specimen which had been collected upon squashes from North Carolina. This material was *C. cucurbitarum* but apparently the name was not published.

*Cunninghamella mandshurica* was isolated in Dairen, Manchuria, apparently from the air. It was said to have conidia ellipsoid to short oval, typically  $26 \times 16 \mu$ , striate, and colored. The sporangia were not recorded. Later Tai made the new combination *Choanephora manshurica* and described the zygospores and sporangia. He showed sporangiospores with bristles, non-striate,  $16.42 \times 9.5-23 \mu$  in size. From the figures and data there appears to be no real difference from *Choanephora cucurbitarum*. The writer follows Zycha (1935) who reduced it to a synonym of *C. cucurbitarum*.

*Choanephorella cucurbitarum* would probably also belong here as a synonym if one knew exactly what Vuillemin was referring to when he stated it was preferable to designate the species, *Rhopalomyces cucurbitarum*, as *Choanephorella cucurbitarum*. Vuillemin gave no reference to, or authority for *R. cucurbitarum*, hence it is not certain that he was referring to Berkeley and Ravenel's *R. cucurbitarum*.

For a complete study of this species the reader is referred to the paper by Wolf (1917) in which he described the zygospores of the fungus and also discussed host relationships.

### 3. CHOANEPHORA INFUNDIBULIFERA (Currey) Saccardo, Syll. Fung. 9: 339. 1891.

1873. *Cunninghamia infundibulifera* Currey, Jour. Linn. Soc. Bot. 13: 334. 1873.  
*Choanephora cunninghamiana* Currey, Jour. Linn. Soc. Bot. 13: 578.

Conidiophores from the host tissue, up to 8.25 mm. high, ending in a primary vesicle, this with stalks bearing secondary vesicles; secondary vesicles with thick walls below and delicate walls above, these collapsing in the thin-walled portion when the conidia fall to give pedicellate funnel-shaped structures; conidia at first white, then brown, finally deep purplish black,  $20 \times 11 \mu$ ; sporangiophores usually shorter than conidiophores, curved at apex, unbranched; sporangia spherical, deep brown, surface tuberculate, with columellae, containing typically 7 or 8 spores, sometimes up to 18; sporangial wall hyaline, rupturing vertically; sporangiospores deep brown, ovoid, not appendaged,  $20-13 \times 13-9 \mu$ ; chlamydo-spores broadly fusiform,  $30 \times 16 \mu$ ; zygospores spherical, deep brown, with a large oil droplet in the center when mature,  $50-70 \mu$  in diam., wall smooth; suspensors tong-like.

Reported upon the flower of *Hibiscus* and on other plants such as *Zinnia* from India. This species was not seen in Wisconsin.

The above description was condensed from an article by D. D. Cunningham (1879). It was Cunningham who collected the material upon which Currey in 1873 based his description of the genus. As explained above, Currey first named the species *Cunninghamia infundibulifera*, then changed it to *Choanephora cunninghamiana* when he discovered that the name *Cunninghamia* was invalid. A number of workers including Zycha (1935) and Naumov (1939), have ascribed this species to Cunningham, but this is incorrect. Cunningham in 1879 merely elaborated upon Currey's original description. When Currey corrected the genus name and changed the species to *Choanephora cunninghamiana* he was still in error, for he had failed to retain the



specific epithet. Apparently Saccardo first used the combination *Choanephora infundibulifera* and even though he ascribed it to Cunningham, who never proposed it, Saccardo must be the authority for the combination.

4. *CHOANEPHORA CONJUNCTA* Couch, Jour. Elisha Mitchell  
Sci. Soc. 41: 143. 1925.

Hyphae well-developed,  $6-16\mu$  thick; conidiophores upright, 2-5 mm. high; conidia borne upon the primary vesicle but more often upon secondary vesicles borne upon branches from the primary vesicle, conidia borne upon the distal half or two-thirds of the vesicle, vesicles funnel-shaped after the conidia have fallen; conidia white, then purplish black, subspherical to ovoid, not striate, usually  $18.5 \times 14.8\mu$ , but varying from  $12-34 \times 9-31\mu$ , light brown with a tint of purple; sporangia formed after the conidia, upon short recurved stalks,  $20-100\mu$  thick, containing 2 to 30 spores; sporangial wall splitting into two halves; columellae spherical to conic, usually with a collar; sporangiospores sub-elliptic, more or less pointed at each end,  $11-21 \times 7.4-11\mu$ , with hair-like appendages, longitudinally striate; gemmae at the ends of delicate threads, oval, smooth-walled,  $20 \times 30\mu$ ; zygospores formed between two isogamous coiled suspensors, spherical, subspherical, or bent elliptic,  $28-66\mu$  in diameter, with an oil droplet, wall colored a golden brown when mature.

Found upon the fading flowers of *Hibiscus syriacus* collected at Chapel Hill, North Carolina.

Since this species was not seen the description is taken from Couch.

DOUBTFUL SPECIES

*CHOANEPHORA SIMSONI* Cunningham, Ann. Roy. Bot. Gard.  
Calcutta 6: 163-174. Pls. 8-9. 1895.

Zycha (1935) treated *Choanephora simsoni* as a synonym of *C. infundibulifera* while Naumov (1939) recognized it as a valid species. The fungus was found parasitizing the leaves and petioles of *Ipomoea* and *Zinnia elegans*. It is said to be smaller than *C. infundibulifera* and to differ by having abruptly truncate vesicles upon which the conidia are borne instead of rounded vesicles as in *C. infundibulifera*. There are ten or more secondary vesicles bearing the conidia. The conidia are fusiform and striate, measuring  $15 \times 8\mu$ . The sporangiospores are fusiform and provided with a striate, brown epispore with radiate, thin bristles and are  $16.8 \times 8.9\mu$ . The zygospores are deep brown to almost black and  $57\mu$  in diameter.

SUMMARY

The Phycmycete family Choanephoraceae, which contains the genera *Choanephora* and *Blakeslea*, is revived. A key to the species of *Choanephora* is presented and the complete synonymy of the genera and species of the family given. Each of the five recognized species of the two genera is described. The occurrence of *Choanephora* in Wisconsin is recorded.

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